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JOURNAL OF DAIRY SCIENCE

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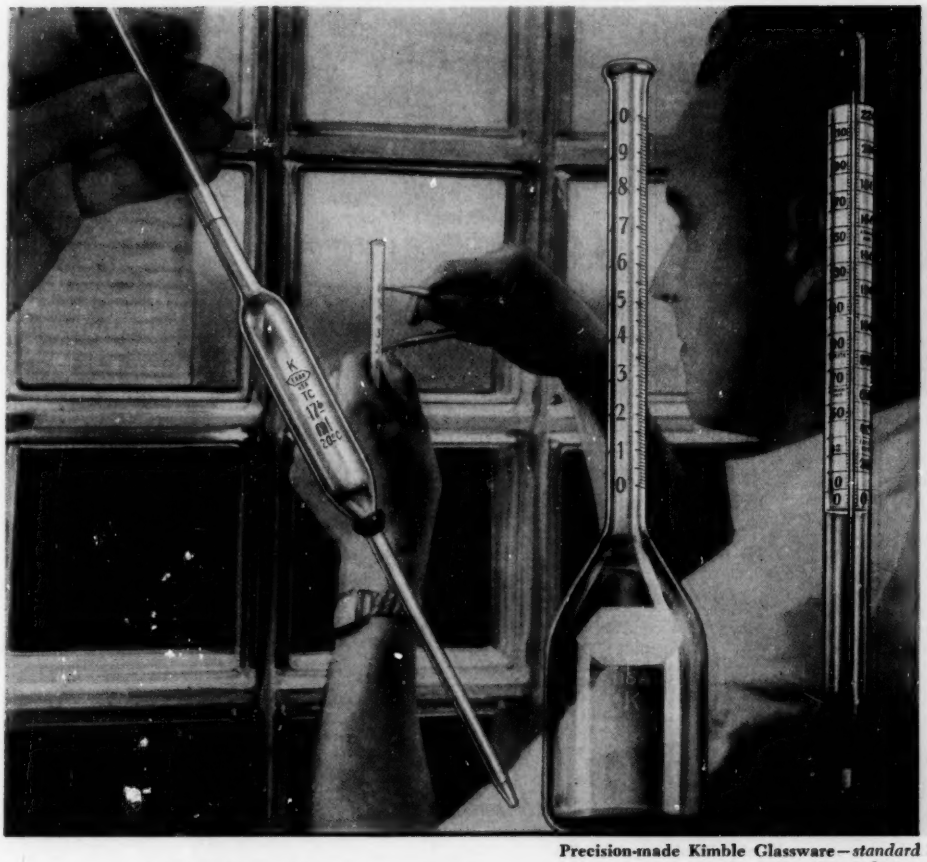

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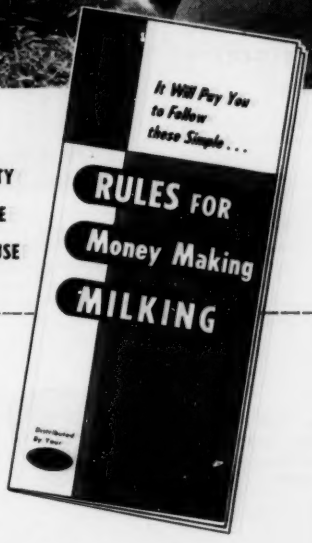

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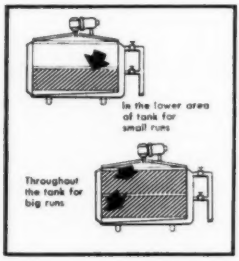

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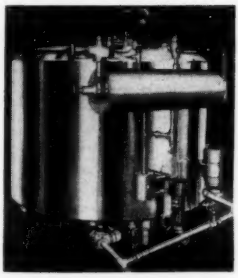

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JOURNAL OF DAIRY SCIENCE

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CHEMISTRY OF MILK FAT: A REVIEW

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Current knowledge of milk fat is brought together here to provide a needed reference and to stimulate additional research in the field. Research on fats has tended to lag somewhat behind that on other biological materials—perhaps because the seeming simplicity of their composition and structure appears not to offer an opportunity for spectacular results, or because the nature of the materials makes research time-consuming and onerous. In any event, other biological compounds have attracted greater attention. But there has been a renewed interest in fats within the last few years, and knowledge of their chemistry has been greatly increased.

A single paper could not well contain all the data pertinent to milk fat, or butter fat, as it is frequently called—incorrectly, the authors believe. In the globular form as it occurs in milk, the lipid material is composed of triglycerides in which are dissolved free fatty acids, possibly mono- and diglycerides for which there are no published values, and a heterogeneous group of materials called unsaponifiable matter. Associated with the triglycerides at the fat globule surface, but probably not dissolved in them, are phospholipids. Aside from listing the amounts of these other materials, from sources believed to be reliable, this review will be confined to the chemistry of the triglycerides and constituent fatty acids.

Milk fat is not a uniform substance. This is evident from the discussion and the variations—often large—in the amounts of the individual constituents shown in the tables. Thus it is not possible to say that an exact quantity of any single component is representative of milk fat. It must rather be said that the amounts of individual constituents—and even of groups of constituents—are best expressed as average values or as ranges of values. To give a single value for any constituent is misleading, and any attempt to characterize milk fat on the basis of the quantity of a single constituent, or even of a group, is fallacious. It is, indeed, doubtful if available data permit one to assign reasonably narrow inclusive ranges of occurrence to most of the constituents.

I. NONGLYCERIDE COMPONENTS OF MILK FAT

A. Phospholipids

Comparatively wide ranges of phospholipids associated with milk fat have been reported in the literature. Because the phospholipids form a part of the

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fat globule membrane complex, the method of obtaining the fat will influence the amounts present. It is generally reported *(165, 180)*, without reference to analytical data, that fat prepared by melting and filtering butter granules contains no phospholipid. Results obtained by the authors *(162)* and by El-Rafey *et al. (34)* indicate that fat prepared by this procedure contains no more than traces of phospholipids. When milk fat is prepared by extraction with solvent from products containing varying amounts of the membrane material and fat, a wide range of values is obtained. Reports in the literature *(27, 58, 87, 143)* indicate a range of 0.655 to 1.048% phospholipids in fat obtained from whole milk by the Mojonnier extraction procedure. Horrall *(87)*, Perlman *(143)*, and Heinemann *(58)* have studied creams of different fat contents and report values of 0.256 to 0.493% phospholipids in the fat. Reference should be made to the original papers for specific values. Reports in the literature on a wide variety of other dairy products are not within the scope of this review.

The phospholipid material in milk has generally been referred to as lecithin, but there is an increasing amount of evidence that substantial quantities of cephalin are also present. The main difference between the two phospholipids is in the nitrogenous component; choline is present in lecithin, and ethanolamine in cephalin. Jack and Dahle *(89)* found the phospholipid material isolated from milk to have an isoelectric point at pH 2.0, which is lower than the isoelectric points generally reported for lecithin and conforms more nearly to the isoelectric point of cephalin. Crane and Horrall *(27)*, analyzing milk phospholipids for choline content, found that lecithin accounted for less than half of the total phospholipids in most of the samples analyzed. Minor amounts of sphingomyelin and cerebrosides also have been reported *(106)* in milk phospholipids.

B. Free Fatty Acids

Although the free fatty acid content of milk fat depends to some extent on the age of the fat and any changes resulting from various treatments, the presence of free fatty acids can always be demonstrated in fresh milk fat. When the fat has been obtained by churning, as reported by Gould and Trout *(43)* and Herrington and Krukovsky *(62)*, the amounts present in fresh fat range from 0.1 to 0.9 expressed as acid degree. The acid degree is the milliliters of 1 *N* alkali required to titrate 100 g. of fat to the phenolphthalein end-point.

Johnson and Gould *(93)* demonstrated that some free acids are lost in churning, and developed a solvent-extraction procedure *(95)* for obtaining the fat. Thomas *et al. (173)* applied this procedure to fresh milk and obtained acid degrees of 0.41 to 1.83, with an average of 0.82. Frankel and Tarassuk *(40)* described an extraction-titration procedure based on the solvent-extraction step of Johnson and Gould, and reported data, for freshly drawn milk that had never been cooled, ranging from 1.50 to 3.50 and averaging 2.01 expressed as free fat acidity (milliliters of 1 *N* alkali required to neutralize the ether extract from milk containing 100 g. of fat). Although solvent-extraction procedures reveal a larger proportion of the fatty acids in fresh milk than does the acid degree of the churned fat, these procedures probably still fall short of quantitative recovery of

all the fatty acids, especially butanoic, which is partly miscible with water. These procedures may also extract nonfat acidic materials.

C. Unsaponifiable Matter

Representative values for the known constituents of the unsaponifiable matter are given in Table 1.

TABLE 1

Composition of unsaponifiable matter of milk fat

Constituent	Range of occurrence
Sterols	
Total cholesterol	2.74-3.34 mg/g fat (134) 3.5 mg/g fat (140) 3.0-3.7 mg/g fat (136)
Lanosterol	Present (123)
Vitamin D	0.23-0.83 IU/g fat (177)
Total tocopherols	42 γ/g fat (57) 12-34 γ/g fat (122) 23-50 γ/g fat (115)
Carotenoids	9.26 γ/g fat (179) 9.45 γ/g fat (121)
Vitamin A	7.37 γ/g fat (179) 8.15 γ/g fat (121)
Squalene	Present (37)
Vitamin K	Present (152)
Unidentified waxes	Present (123)

Whether cholesterol is present both as free cholesterol and as the ester is uncertain. Although Nataf *et al. (131)* found no evidence of cholesterol esters, Nieman *et al. (136)* reported values for them. In addition, the amounts of vitamin D depend upon feed and the amount of sunlight available to the cows, both of which vary from place to place and season to season. It should be noted that a substantial portion of the unsaponifiable matter has never been characterized.

II. Chemistry of the Triglycerides

It has been recognized since the work of Chevreul *(22)* that true fats are glycerol esters of fatty acids. The chemistry of the triglycerides depends on the component fatty acids, their configuration, and their arrangement in the glyceride molecule.

A. Fatty Acid Composition of Milk Fat[1]

Major Component Fatty Acids. Knowledge of the component fatty acids in milk fat has increased as analytical methods available to researchers in the field have improved.

[1] The modification of the Geneva System of Nomenclature, as used by *Chemical Abstracts*, will be used where applicable throughout this review.

TABLE 2

Major fatty acid components of milk fat

	Component acids—Mol %					
	Holland *et al. (84)*	Hilditch and Longenecker *(70)*	Hilditch and Paul *(71)*	Smith and Dastur *(160)*	Hansen *(49)*	Jack and Henderson *(90)*
	Iodine value 27.999	Iodine value 37.5	Iodine value 46.9	Iodine value 36.6	Iodine value 39.6	Iodine value 32.42
	(Calc. from wt. %)					
Saturated						
C_4	8.7	8.1	10.2	9.7	10.5	9.2
C_6	2.8	2.8	2.5	1.2	3.9	2.8
C_8	1.7	2.5	1.3	1.6	1.8	2.7
C_{10}	2.6	3.7	1.5	2.5	3.3	3.5
C_{12}	8.4	4.4	3.4	3.0	3.8	5.2
C_{14}	24.2	12.5	8.6	12.5	9.8	14.8
C_{16}	15.8	23.2	21.1	22.1	23.3	27.2
C_{18}	10.0	7.6	9.9	9.8	11.6	8.5
C_{20}	—	1.0	0.7	0.8		1.2
Unsaturated						
C_{10}	—	0.4	0.2	0.3	0.3	0.3
C_{12}	—	0.9	0.2	0.3	0.3	0.2
C_{14}	—	1.7	0.9	1.0	1.2	1.5
C_{16}	—	3.7	2.8	3.0	1.9	5.2
C_{18}	27.2	24.8	31.4	30.5	26.8	15.3
C_{20}	—	0.2	0.5	0.6	1.6	0.7
Octadecadienoic	—	2.9	4.9	1.0	—	1.7

Table 2 shows the major component fatty acids and the range of values determined by several different investigators. Browne *(21)* was one of the first investigators to make a detailed analysis of the fatty acid composition of milk fat. In his method the fatty acids were liberated from the glycerides and separated into water-soluble and water-insoluble groups. The composition was calculated from the neutralization number of each fraction.

Ester distillation was subsequently introduced as an analytical tool, and the most complete data for this method among the early reports were those of Holland *et al. (84)*. Hilditch and Longenecker *(70)* analyzed milk fat by the ester-fractionation method, adding the improvement of an electrically-heated, packed, distilling column. Hilditch and Paul *(71)* further improved the method by separating the fat into different fractions by precipitation from solvent before distillation.

Later reports in the literature are based upon the use of these improved techniques. Smith and Dastur's studies *(160)* were concerned with the effects of inanition on the composition of milk fat; the data of Jack and Henderson *(90)* cover results obtained by more extensive preliminary fractionation; those of Hansen *(49)*, and Hansen and Shorland *(52)* are representative of milk fat produced under New Zealand conditions.

One of the difficulties in the ester fractionation techniques has been to make an accurate estimation of the lower fatty acids. Chromatography is now an added

technique that improves the resolution of these components *(35, 137, 146, 147)*. Most of the developmental work in the field has been done by Holman and his associates *(85)* and Kaufman *et al. (97, 98)*. James and Martin *(92)* used a unique gas-liquid partition method for the separation and micro-estimation of volatile fatty acids. They obtained complete resolution, from formic through dodecanoic acid, by using a 4-ft. column.

Another limitation on ester fractionation by distillation has been the difficulty of separating into different fractions the methyl esters of the higher unsaturated acids that each contain the same number of carbon atoms. Brown and associates *(19)* developed a low-temperature fractional crystallization technique, which has been widely employed to separate unsaturated fatty acids or their esters from mixtures. Schlenk *(151)* reviewed the formation of urea inclusion compounds of fatty acids. Swern and Parker *(169)* and others *(155)* used the preferential formation of urea inclusion compounds to separate oleic acid or methyl oleate from polyethenoid materials. Holman *et al. (85)* have also demonstrated the value of chromatography in separating the unsaturated as well as the saturated acids. Several investigators *(26, 60, 156, 163)* employed combinations of the above techniques to concentrate the polyethenoid constituents of milk fats.

Although the actual isolation of most of the polyethenoid components of milk fat has not been accomplished, they have been estimated by ultraviolet spectrophotometric techniques. Table 3 shows the amounts of these constituents as determined in milk fat by different investigators. Traces of nonconjugated pentaenoic acids also have been detected *(158, 164)*.

The values for low molecular weight fatty acids and unsaturated fatty acids are not as precise as those for the others because of the limitations of current isolation procedures.

Minor component fatty acids. Data purporting to show the presence of vaccenic acid (11-octadecenoic acid) in milk fat have been presented by several workers *(11, 12, 16, 41, 48)* and special growth-promoting properties have been ascribed to this acid *(13)*. Later reports have shown that the special growth-promoting properties could not be substantiated *(30, 135)*, but the presence seems established of a transmonoethenoid acid with a double bond elsewhere than in the "9" position.

The thesis for the presence of vaccenic acid stems originally from a paper by Bertram *(11)*. He isolated from beef tallow (jus) a solid unsaturated acid that he termed vaccenic acid (vacca, for cow). He assigned the double bond to the "11" position because the molecular weights and melting points of the disruptive oxidation products (ozonolysis) corresponded with those of heptanoic acid and nonanedicarboxylic acid. Bertram assigned a trans configuration to the acid because he was unable to convert it to a higher melting form with isomerizing agents. He was able to isolate from milk fat a small amount of material corresponding in melting point and iodine value with the acid obtained from beef tallow.

Gupta *et al. (48)* verified Bertram's original observations except that, using potassium permanganate in acetone as the oxidizing agent, they were able to

TABLE 3

Polyethenoid fatty acids of milk fat

	Per cent					
	Conjugated			Nonconjugated		
	Diene	Triene	Tetraene	Diene	Triene	Tetraene
Mattsson *(119)*	0.6 -3.7	———	———	0.8 -2.0	0.7 -2.0	———
Schaffer and Holm *(153)*	———	———	———	2.62-2.71	0.77-1.17	———
Morris *et al. (125)*	0.64-1.45	0.010-0.030	0.0012-0.0044	———	———	———
	av. 1.00	av. 0.019	av. 0.0030			
Lembke *et al. (110, 111)*	0.65-2.1	0.035-0.07	0.0046-0.0072	———	———	———
McDowell *(120)*	0.7 -1.4	0.02 -0.04	Nil	0.2 -0.7	0.5 -1.0	0.3 -0.4
Smith and Jack *(164)*	0.74-1.08	0.02 -0.03	0.002 -0.004	1.16-1.59	0.73-0.97	0.28-0.44
	av. 0.89	av. 0.02	av. 0.003	av. 1.45	av. 0.83	av. 0.35

obtain nonanedicarboxylic acid (as a split product) only from milk fat, and then in very small quantities. On the other hand, they obtained not only heptanoic acid but also substantial proportions of octanoic acid. In fats other than milk fat, the amount of octanoic acid exceeded that of heptanoic. These workers believed that their data indicated not only trans-11-octadecenoic acid but also trans-10-octadecenoic. Gupta *et al.* suggested that there was good reason to believe that the cis forms of these acids should also occur. The techniques used for the trans forms would not reveal them.

If one follows this line of reasoning further, it seems probable that monoethenoid acids might occur with the double bond in any one of several positions, and as either geometric isomer. Evidence on this point is not available, and perhaps the efforts to obtain such evidence would be disproportionate to the importance of the results at the present time.

The occurrence in milk fat of fatty acids with branched chains and uneven numbers of carbon atoms has been reported by New Zealand investigators. Hansen and Shorland *(50, 51, 53)* isolated two isomeric C_{17} acids—15-methyl-hexadecanoic and 14-methyl-hexadecanoic—and a C_{20} saturated acid fraction containing at least three, and possibly four, methyl groups. Hansen *et al. (54, 55)* isolated a C_{18} methyl branched-chain saturated fatty acid and two isomeric C_{15} acids, 12-methyl-tetradecanoic and 13-methyl-tetradecanoic. Shorland *(157)* isolated pure *n*-pentadecanoic acid from milk fat.

The possible presence of hydroxy fatty acids in milk fat has been suggested by Okey *(141)* to explain certain results obtained when cholesterol determinations were made on this fat. Henderson and Jack *(60)* also observed a solvation of some of their fractions that might be attributed to hydroxy fatty acids. Investigations in this direction might prove fruitful in revealing other undetermined constituents.

Physical properties of the fatty acids. For tables giving extensive lists of physical properties, the reader is referred to recent comprehensive monographs by Markley *(118)*, Ralston *(145)*, Bailey *(5)*, and Deuel *(29)*.

Fatty acid configuration. Figure 1 (1) shows a diagrammatic arrangement of atoms in a saturated fatty acid molecule but the principal interest in this subject centers around positional and geometrical isomerism in the unsaturated fatty acids.

Hilditch and Longenecker *(70)* showed by oxidation procedures that the double bond of the monoethenoid series, which ranges from C_{10} (decenoic) to C_{18} (octadecenoic), was located between the ninth and tenth carbon atoms. The presence of a terminal double bond in decenoic acid has been confirmed recently by Smith *et al. (161)* using infrared spectroscopy. The basis for other locations of the double bond has been discussed above (*vide* vaccenic acid).

It is only recently that reasonably reliable methods have been available to investigate the possible conjugation of double bonds in the polyethenoid acids, all of which are 18 carbons or longer. The chemical method of analysis for the nonconjugated polyethenoid components, linoleic (9, 12-octadecadienoic), linolenic (9, 12, 15-octadecatrienoic), arachidonic (5, 8, 11, 14-eicosatetraenoic) acids,

based on the determination of iodine number and thiocyanogen number, is difficult; and when these compounds are present in small proportions, it is inaccurate. Tests based on the formation and isolation of bromination products are also insensitive and unreliable in such cases. A reliable chemical method is not yet available to determine the minor conjugated constituents. However, recently developed ultraviolet spectrophotometric methods have provided useful tools to determine both conjugated and nonconjugated acids of milk fat *(vide* Table 3).

With the exception of vaccenic acid (trans-11-octadecenoic), the monoethenoid fatty acids of milk fat have generally been assumed to be exclusively of cis configuration. However, Cornwell *et al. (26)* and Smith *et al. (161)* reported the presence in milk fat of trans isomers of octadecenoic acid by infrared spectrophotometric analyses. The latter also presented evidence for the occurrence of trans isomers of hexadecenoic, tetradecenoic, and dodecenoic acids. Cornwell *et al.* suggested, on the basis of solubility, the presence of a unique trans acid with the double bond probably in the "14" position or beyond.

Early workers *(18, 63)* postulated that milk fat–linoleic acid was actually a mixture of cis-trans- and trans-cis-9, 12-octadecadienoic acids because no petroleum ether-insoluble tetrabromide could be isolated. White and Brown *(178)* concentrated the octadecadienoic acids and found approximately two-thirds of the material was ordinary linoleic, the remainder being presumably the cis-trans and trans-cis isomers. On the other hand, Shorland *(156)* has reported that the octadecadienoic acid of New Zealand milk fat is not linoleic, although the octadecatrienoic acid content consisted almost entirely of linolenic acid. Perhaps the experimental difficulties involved and possible differences in the feed of the cows may explain such conflicting reports in the literature.

Although ultraviolet and infrared spectrophotometric methods are valuable tools for configuration study, they do not reveal the actual location of the double bonds, except for terminal double bonds, or the order of arrangement of cis and trans double bonds in the carbon chain.

B. Influence of Various Factors on Fatty Acid Composition

An evaluation of the effects of specific factors on the fatty acid composition of milk fat is clouded by the fact that it has seldom been possible to control all conditions surrounding the production of milk so that only one variable is operative at any one time. Usually when feed conditions have been varied there have also been climatic or seasonal changes, differences in stage of lactation, and possibly also, although frequently obscured, variations in the plane of nutrition. In spite of the uncertainties involved an attempt will be made to evaluate the effects of these factors.

Feed. There is ample evidence that the character of feed influences the composition of the fat produced from it. Hilditch and associates *(67, 68, 72, 74)* showed that concentrate feeds containing seed oils rich in octadecadienoic and octadecatrienoic acids do not affect the composition of the milk fat produced from them, but that when feeds containing dodecanoic and tetradecanoic acids are fed,

the proportions of these acids increase in the fat produced. Also, when feeds contain fish oils the characteristic polyethenoid C_{20} and C_{22} acids appear in the milk fat. There have been numerous other reports of the effects of different grains and concentrate feeds on the character of the fat produced, but these have been reported as changes in some chemical constant of the fat rather than being documented by fatty acid analysis.

Hansen and Shorland *(52)* considered that the influence of diet on the fatty acid composition of milk fat should remain substantially the same during the grazing season because the fatty acid content of grass is so small—2 to 4%—and its main unsaturated constituents are found in such small amounts in milk fat. Workers in Holland *(1, 14, 15, 17)* on the other hand, have made extensive studies of the effects of hays and grasses upon the resulting fat. Fluctuations in iodine value of the milk fat are closely allied with the octadecenoic acid content of the feed, which is considerably higher in grass and clover pastures than in hay. Brouwer and Frens *(15)* reported that nitrogen-fertilized pastures enabled the cows to produce fat with an iodine value 3.7 units higher than that from non-nitrogen fertilized pasture. Bartley *et al. (7)* substantiated the effect of pasture in increasing the unsaturation of milk fat; they attributed the increase mainly to octadecenoic acid. Mattsson *(119)* reported that summer-pasture fat contains more conjugated C_{18} acids than that produced on winter fodder.

It seems well established, therefore, that the composition of feed will influence to some extent the fatty acid composition of the fat produced from it.

Plane of nutrition. Several investigators *(23, 32, 150, 160)* have shown that underfeeding affects the chemical composition of milk fat. The results have been reported generally in terms of chemical and physical constants, except for Smith and Dastur *(160)*, who presented fatty acid composition analyses. The results agree that a lowered plane of nutrition results in a decrease in the volatile, or low molecular weight, fatty acids and an increase in the unsaturated fatty acids, principally octadecenoic.

Environmental temperature. Regan and Richardson *(148)* showed that temperatures of 85° F. and above affect the composition of milk by decreasing the solids-not-fat, and that at 95° F. the Reichert-Meissl value of the fat decreases and the iodine value increases sharply. The question arises as to whether it is the effect of temperature per se or whether the changes are the result of "hyperthermic undernutrition." Eckles and Palmer *(32)* pointed out that all types of underfeeding cause a decline in the volatile acids and an increase in the degree of unsaturation of the fat. This viewpoint is supported by fatty acid analyses by Smith and Dastur. The data of Bartley *et al.* are in agreement with respect to the effects of temperature in experiments where the daily temperatures did not exceed 83° F. They could find no correlation between temperature and the iodine value of the fat, which lack of correlation would be expected from the temperatures experienced under their conditions.

Stage of lactation. Data purporting to relate to the effects of stage of lactation are so confused by the possible influence of other factors—such as changes in diet and plane of nutrition, *i.e.*, whether or not the animal is using body fat—that

a clear-cut analysis is not possible. Some data *(33, 84, 149)* appear to show that there is a steady decrease in volatile acid content and a gradual increase in iodine value as lactation progresses. These are the results that would also be expected from a steady decline in the plane of nutrition, a condition that frequently accompanies the progress of lactation. Was this the operative factor in these results, or was it lactation per se? Bartley *et al.* and Hansen and Shorland *(52)* report that there is a rather rapid decrease in the unsaturated acids during the early stages of lactation, followed by a leveling off and gradual increase toward the end of the period. The latter authors conclude that it is not possible to differentiate between the effects of stage of lactation and plane of nutrition.

In considering the interrelationships among the factors discussed above, two conclusions seem to be justified: The composition of the feed from which milk is produced may affect the composition of the fat; and a lowered plane of nutrition that causes the animal to use body fat for milk fat production will result in a decrease in the volatile fatty acid content and an increase in the degree of unsaturation of the milk fat. At the present time the evidence does not justify an attempt to distinguish among the effects of lactation, environmental temperature, and plane of nutrition.

C. Glyceride Composition of Milk Fat

The composition of the individual glycerides will depend on the number of fatty acids available for glyceride constitution. Because there are undoubtedly at least twenty different fatty acids present in milk, the number of glycerides theoretically possible has been shown to be 20^3, or 8,000; and even when one considers only the possibilities resulting from those acids present in substantial quantities—about 13—there will be 13^3, or 2,197, different glycerides. Obviously it is impossible to determine all of the exact glyceride combinations that might be present. However, because of the value of such knowledge to the understanding of milk fat synthesis, the specificity of lipase activity, and the probable mechanisms of absorption and utilization in the human body, it has seemed worthwhile to numerous investigators to determine specific groupings and then to apply generalizations.

Constituent glycerides. It was many years after Chevreul *(22)* showed that fats were composed of glyceride esters of the fatty acids before it was realized that these were not simple triglycerides, even though logical reasoning might have suggested the fact and should have provoked investigation. The first real evidence that milk fat was not composed of simple triglycerides was offered in 1913 by Amberger *(2)*. By means of fractional crystallization and isolation of individual glycerides he was able to separate several mixed glycerides from milk fat.

In 1927 Hilditch and Lea *(69)* developed an oxidation procedure by which the fully saturated glycerides could be separated from those containing unsaturated components. By using these techniques of fractional crystallization and oxidation it has been possible since that time to separate the glycerides into

four categories, depending on the number of saturated fatty acids in the molecule. These have been characterized as GS_3, GS_2U, GSU_2, and GU_3—where G represents the glyceride component, S the saturated fatty acids present, and U the unsaturated fatty acids present in the glyceride molecules. In 1931 Hilditch and Sleightholme *(73)* were the first to discuss in detail the glyceride structure of milk fat as established by these procedures. In 1952 Greenbank *(46, 47)* fractionated milk fat in absolute alcohol and studied the glyceride structure of the different fractions. He concluded that most of the glycerides were GSU_2 and GS_2U.

Relationships have been worked out from the proportions of the different types of fatty acids present in the different groupings in milk fat, and attempts have been made to formulate general rules of occurrence. A molecular, or "association," ratio of saturated to unsaturated acids in the non-fully saturated portion of the fat permits calculation of the proportions of the unsaturated glycerides or indicates the limiting values that must obtain. Banks and Hilditch *(6)* originally proposed as a result of such considerations that the distribution pattern of fatty acids follows the rule of even, or widest, distribution in fats from the plant kingdom and that fats from animal sources are distributed in a random pattern. However, later results *(65)* caused Hilditch to suggest that animal fats also follow a modified even-distribution pattern in which the saturated acids are arranged according to random distribution but the unsaturated acids follow the even pattern. According to Hilditch *(64)* in a pattern of even, or widest, distribution a fatty acid will not repeat itself in a molecule until it forms more than 33 to 35% of the total fatty acids; when it forms 35 to 65% of the total acids, it may be expected to repeat twice in some or all of the molecules; nonmixed glycerides will appear only when the content of a single fatty acid is above 65%.

On the other hand, Longenecker *(112)* has supported the thesis that all natural fats follow the pattern of random distribution. In random distribution the proportion of occurrence of any specific glyceride is governed by the laws of chance according to the following equation: Molar percentage of any specific glyceride $= n \times [(a \times b \times c)/100^2] \times 100$, where n = frequency of the glyceride occurrence in random distribution and a, b, and c = molar percentage of the fatty acids in positions 1, 2, and 3 of the glycerol respectively. For example, if the fatty acid mixture contains 63% saturated acids, according to the even distribution theory the amount of fully saturated glycerides would be negligible, whereas with random distribution the molar percentage of fully saturated glycerides would be 25.

The controversy has centered around these two points of view, and various modifications have been proposed to fit the data better. Norris and Mattil *(139)* supported the viewpoint of random distribution, stating that such a pattern represents a chemical equilibrium, whereas in the even distribution pattern the glycerides are not necessarily in equilibrium with their surroundings, because they must have been formed by a directed rather than a random synthesis. Doerschuk and Daubert *(31)* proposed a modified random distribution pattern,

whereas Luddy *et al. (113)* in three of four different fats found no correlation with either random or modified random distribution patterns. Reiser and Dieckert *(149)* attempted to solve the problem in fat synthesis by studying rats and chicks: Some were on an extremely low-fat diet leading to endogenous fat synthesis; others were on diets providing fats from various sources, including fat from their own species. With rats the fat from endogenous synthesis showed a random pattern but ingested fat conformed to even distribution; the chicks demonstrated a tendency to form simple triglycerides regardless of diet.

Aside from the contributions of Hilditch and associates *(64, 65, 67, 70, 71, 73)*, the reports relating to milk fat are not extensive. Jack *et al. (91)* presented data on mixed milk fat that conformed closely to the pattern predicted by even distribution. Sommer *(166)* has commented, however, that whenever fat samples from different sources are mixed the distribution patterns, which might be affected by differences in diet and physiological factors, are also mixed and close adherence to any mathematical relationship should not be expected. Kartha *(96)* showed data for cow milk fat that he claimed supported the arguments for a restricted random distribution pattern proposed by him. Hilditch *(66)* in a recent reply to Kartha's paper casts doubt on the validity of some of the experimental data and disagreed with Kartha's analyses of existing data. Hilditch referred to data about to be published, which he says will substantiate further the general postulate of even distribution.

It is apparent that little can be said definitely at present concerning the distribution pattern of fatty acids in milk fat. Considerable space has here been devoted to the general subject to show some of the difficulties involved and the divergent views that have been presented. The complexity of the problem indicates that a complete solution will not soon be achieved with the techniques at hand. Labeling fats in vivo with radioactive isotopes and subsequent isolation and characterization of the resulting individual glycerides suggests itself as a possible approach.

III. PHYSICAL STRUCTURE OF MILK FAT

It is not sufficient to consider solely the chemical composition and distribution pattern of the glycerides; the physical structure must also be studied, both with respect to the geometry and the crystalline habit of the glyceride. Such knowledge is important for its direct bearing on technological problems; it is of increasing importance in its application to the study of composition. Dairy scientists have long been concerned with research on the practical aspects of technology. Numerous studies dealing with cooling procedures, solidification points, and melting points—and sometimes their interrelationships—have appeared in the literature. The majority of these investigators have drawn conclusions based upon analogous behaviors as determined in simple systems.

Relatively few studies of milk fat have dealt directly with fundamental aspects of the problem. Van Dam and Burgers *(176)* published results of X-ray diffraction studies. However, at that time such studies yielded but little knowl-

edge of either the geometry of the molecule or the crystalline patterns. Jack *(88)* studied melting rates of fats crystallized by different procedures and related these to possible crystalline patterns. Rishoi *(151)* reviewed the thermal behavior of milk fat in rapidly cooled cream, and Mulder *(133)*, in studying melting and solidification of milk fat, arrived at the conclusion that it existed in the solid form as mixed crystals. For a more complete understanding of the geometry of glycerides and the crystalline habit of fats, it is necessary to refer to studies made upon relatively simple systems.

It is beyond the scope of this review to discuss in detail all of the material available on this subject. The reader is referred to recent excellent reviews by Lutton *(114)* and Malkin *(116, 117)* and to the monograph by Bailey *(5)*. Two proposed general patterns of glyceride structure have been based on knowledge of bond angles and bond distances within the molecule. These are the so-called "tuning fork" structure and, in certain cases, the "chair" structure which are shown in Figure 1 (II, III). The reader is referred to the publications cited above for the arguments supporting these postulates.

Techniques have not yet been developed to determine the positions of specific fatty acids on the glycerol molecule in mixed triglycerides.

X-ray diffraction studies and melting point data are used to examine crystal structure of fats. From X-ray diffraction spacings, three distinctive crystalline forms are generally recognized in glycerides—called α, β', and β, in an ascending order of melting point. Clarkson and Malkin *(24, 25)* proposed a fourth form, designated as "vitreous." Although X-ray diffraction data are not recorded for this form, the evidence for its existence seems clear-cut.

It is obvious that the application of these techniques and this knowledge to milk fat will result in a more thorough understanding of many of the problems confronting the dairy scientist. The complexity of milk fat renders direct application difficult, but it is nevertheless desirable. The isolation of less-complex glyceride mixtures, and preferably individual glycerides, should be done because extensive data are available on the characteristics of triglycerides of known constitution. Crystallization, distillation, countercurrent separations, and other techniques of detailed fractionation now available should be brought to bear on the problem.

IV. CHEMICAL REACTIONS OF MILK FAT GLYCERIDES

Milk fat glycerides are subject to all the general chemical reactions of glycerides, but only a few have been studied. Analytical reactions—such as with alkali in determining saponification values and with halogens in determining the degree of unsaturation—are standardized and need not be discussed here. Two reactions that result in deterioration of milk fat in commercial usage—hydrolysis and oxidation—are considered here, but only briefly, inasmuch as extensive pertinent reviews have been published recently *(61, 167)*.

Hydrolysis. Hydrolysis of milk fat involves a reaction between the glycerides and water. It may stop at partial hydrolysis, with the formation of mono- and

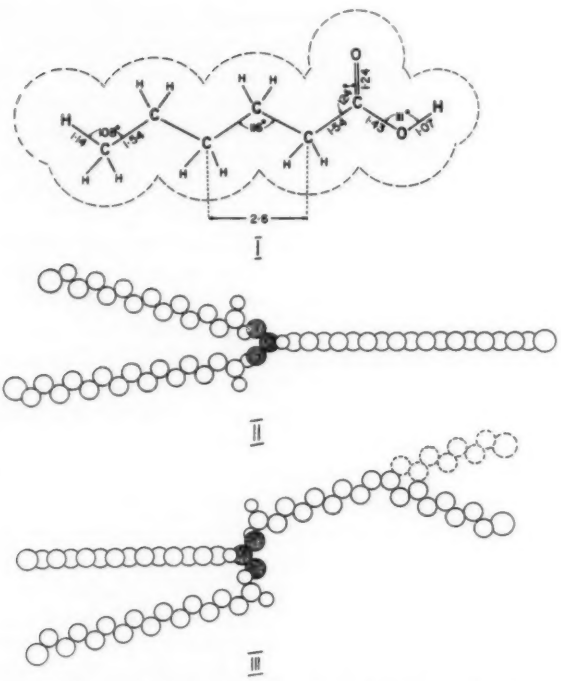

FIG. 1. Structure of fatty acids and triglycerides. I. Possible positions of atoms in a molecule of hexanoic acid (caproic). Angles between the bonds that join the atoms are indicated in degrees, and the lengths of the bonds are given in Angstrom units. The angle between the carbons of the hydrocarbon chain is that accepted by Malkin *(116)* from X-ray diffraction patterns of crystals. Values for the other bond angles and the interatomic distances are taken from Daniels *(28)* and from Noller *(138)*. II and III. 2-stearomyristopalmitin and 2-myristo-oleopalmitin molecules, illustrating "tuning fork" and "chair" configurations. Large, medium, and small circles represent methyl groups, carbon atoms, and oxygen atoms, respectively. Dotted circles are carbon chain of glycerol. Hydrogen atoms of chains are omitted. Dashed carbon chain shows a greater structural regularity for the trans isomer (elaidic) than the cis isomer (oleic) of 9-octadecenoic acid.

diglycerides, or proceed to a complete splitting of the component fatty acids and glycerol. When the reaction is chemically catalyzed in the laboratory, a far greater degree of hydrolysis is obtained than in the enzymatic hydrolysis of fat occurring in biological systems. Generally, in milk fat, the reaction has been studied with respect to the action of the catalysts involved and the resultant fatty acids rather than from the standpoint of the remaining glyceride fragments.

It is well known that hydrolysis of milk fat is catalyzed both by H-ion and by enzymes, and it is the latter that have received the most attention from research workers. Herrington *(61)* published a comprehensive review on lipase in milk, and the mode of action of these enzyme systems will not be touched upon here. Hillig *et al. (75, 76, 77, 78, 79, 80, 81)* and others *(4, 56)* developed methods

for assaying the fatty acids liberated in deterioration of butter and cream through the action of enzymes and acids. These have been determined as water-soluble acids and water-insoluble acids.

An aspect of lipase activity suitable for consideration here is that of possible specificity of action. Lipolysis in milk has been described as being of two different types, spontaneous and induced. Tarassuk and Jack *(172)* considered that the differences between spontaneous and induced lipolysis are attributable to differences in the enzyme systems involved. Krukovsky and Sharp *(104)* and Kelley and Dunkley *(102)* believed that the specific differences are related to changes in the nature of the surfaces of the fat globules.

The question arises whether lipolytic enzymes catalyze the hydrolysis of fat indiscriminately or whether some are more effective than others in liberating certain fatty acids. It is generally stated that lipases as a class have a low degree of specificity, being able to hydrolyze not only fats but also simple esters. Studies with simpler substrates and lipases from sources other than milk *(3)* indicate that the ease with which glycerides are split increases with the chain length—perhaps contrary to enzyme systems generally, where activity may decrease with increasing molecular weight *(59)*—and with unsaturation of fatty acids. Thus there is a fundamental basis for the possibility of some degree of specificity of lipase activity or differences in the relative rates at which hydrolysis of different triglycerides will occur.

Gould *(12)* and Johnson and Gould *(94)* determined the chemical characteristics—including acid degree, Reichert-Meissl, Polenske, saponification and iodine values—of fractions obtained from fresh and rancid milk fats, but the data gave no definite indication of selective fat hydrolysis by the lipase system. Gould considered that his results offered some basis for assuming that milk lipase acts on all of the triglycerides present and to about the same extent; but he pointed out that a more specific identification of the fatty acids involved is necessary before final conclusions may be drawn. Some results obtained in this laboratory *(39)* tend to show that induced lipolysis of homogenized raw cream yielded a higher percentage of volatile acids than spontaneously rancid cream. These latter results are in keeping with reported observations in commercial practice in which marked flavor differences are ascribed to the different types of lipolysis produced under different activating conditions.

The question of lipase specificity in milk should be studied with reasonably pure enzyme fractions and less complex glyceride substrates of known composition.

Oxidation. The voluminous literature pertaining to the oxidative deterioration of lipids has been recently reviewed by Holman *(86)*, Morris *(125)*, and Lea *(108)*. Because of the complexity of the oxidation of natural fats, most of the fundamental concepts are supported by evidence obtained from studies of known mixtures of fatty acids and esters.

Oxidation of fats by molecular oxygen is generally caused by an initial reaction between oxygen and the component fatty acids. Both saturated and unsaturated fatty acids are susceptible to oxidation, but the rate of uptake of oxygen

increases with the degree of unsaturation of the fat and the postulated mechanisms of oxidation for the various types of fatty acids are different. However, it is generally accepted *(125)* that in the autoxidation of nonconjugated fatty acids a free radical first forms on the α-methylene group, adjacent to a double bond. The free radical absorbs an oxygen molecule, which then accepts hydrogen to form a hydroperoxide. The hydrogen usually comes from another fatty acid or ester, to form another free radical, and thus the chain reaction continues. In the oxidation of monoethenoid acids, which have less active methylene groups, the addition of oxygen occurs initially at the double bond instead of at the α-methylene group, providing the free radicals necessary for the usual α-methylenic free radical chain reaction to proceed.

Secondary products are derived in great variety from the decomposition of the peroxides initially formed. Relatively little is known about their structure or the mechanisms by which they are formed, but they include various aldehydes, ketones, and acids. The shorter chain decomposition compounds responsible for oxidized odors and flavors can be detected organoleptically when only a few parts per million are present.

For information concerning the details of the mechanisms of autoxidation, the chemical tests used to measure the extent of oxidative changes occurring in fats, the evaluation of oxidative stability of fats, and the use of antioxidants, the reader is referred to the reviews cited above and to the publications of Bateman *(8)*, Lea *(107)*, Beadle *(10)*, and Kraybill and Dugan *(103)*.

The oxidation of milk fat that occurs in milk and dairy products is complicated by the presence of nonglyceride components, which may differ from triglycerides in susceptibility to oxidation, and by the fact that the reactions frequently take place in an aqueous system. For example, the phospholipid fraction of milk is oxidized more readily than is the glyceride fraction and generally has been considered the major source of oxidized flavors in milk *(45, 168, 175)*. On the other hand, Pont *(141)*, who used the sensitive ferric-thiocyanate method for the determination of peroxide values, concluded that glyceride oxidation plays a significant part in the development of such flavors. Reviews on oxidized flavor in milk and dairy products—by Brown and Thurston *(20)*, Greenbank *(44)*, Hills *(82)*, Mukherjee *(126, 127, 128, 129, 130, 131, 132)*, Lea *(109)*, and Strobel *et al. (167)*—emphasize the numerous factors that influence the oxidation of the glycerides and associated lipids.

The influence of fatty acid composition on oxidation of milk fat is difficult to assess because factors such as feed, which produce marked changes in the amounts of various fatty acids, also affect the contents of carotenoids and tocopherols, and possibly of other pro- and anti-oxidants *(105)*. Thomé and Mattsson *(174)* reported that the oxidation of milk fat, as measured by the increase in peroxide value, takes place in two stages: a more or less lengthy induction period and an active oxidation period. They considered that the induction period is regulated by natural antioxidants in the milk fat, which can vary with feed of the cow. Furthermore, they showed that milk fat with a comparatively high content of conjugated C_{18} and of linoleic acids will have a shorter

induction period and a higher rate of oxidation during the active period than will milk fat with a low content of these acids. Sidwell *et al. (159)* measured the oxidation of several fats, including milk fat. They plotted peroxide and total carbonyl values of the fat, and TBA[2] and total carbonyl values of the volatile products, as rate curves. The rate of increase in each case was much lower for milk fat than for lard and for soybean and cottonseed oils. Such differences as these between the oxidative stability of milk fat and of other food fats perhaps can be attributed to differences in the course of autoxidation of milk fat that are related to fatty acid composition and the presence of pro- and anti-oxidants.

Comparatively few conclusive studies have been made on the materials produced during the oxidation of milk fat and on the specific substances responsible for oxidized odors and flavors. Keeney and Doan *(99, 100, 101)* found that vacuum distillation of oxidized milk fat yielded materials (identified as unsaturated ketones) containing the characteristic odor compounds of oxidized fat. During advanced stages of milk fat oxidation, they were able to isolate flavor fractions typical of earlier stages in the oxidation process. They concluded that changes in flavor during autoxidation were caused by a blending of different flavor compounds. Thomé and Mattsson *(171)* believed that the substances actually causing the flavor defect were α, β-unsaturated carbonyl compounds, aldehydes, and ketones. Tamsma *(170, 171)* removed a volatile fraction from oxidized milk fat by deodorization and subsequent solvent-extraction of the distillate. This fraction was found to contain three classes of carbonyl compounds of ketonic character. The nonconjugated unsaturated compounds were responsible for the oxidized flavor, and both the carbonyl group and unsaturation were necessary.

It seems well established that various unsaturated carbonylic compounds contribute to oxidized flavors of milk fat. Furthermore, the deterioration of this fat can be detected organoleptically at very low levels of oxidation as estimated by objective chemical tests *(82, 83, 111)*. The odor and flavor of milk fat change during successive stages of the oxidation process, but the available data indicate that the flavor observed at any one time cannot be attributed to any single compound. Although simple objective chemical tests, such as peroxide value, will continue to be of value in studying the oxidation of milk fat and associated lipids, further work is needed to isolate and identify the compounds associated with oxidized flavor. The trace amounts of such materials, especially during the early stages of oxidative deterioration, and their relative instability make the task difficult, though nevertheless desirable.

Other reactions. Patton *et al. (142)* reported in dry whole milk and butter oil a lipid-phase deteriorative flavor that they believed to be nonoxidative in nature but to involve lactone formation in glycerides containing 9-decenoic and 9-dodecenoic acids.

The only other chemical reaction that will be discussed in this review is that of inter-esterification. There are, as yet, no published results on such studies with milk fat.

[2] TBA = 2-thiobarbituric acid.

Baur *(9)* and Feuge *et al. (36)* studied inter-esterification of glycerides with triacetin and with acetic anhydride. Formo *(38)* reviewed ester reactions of fatty materials. Interesting compounds can be produced that have a wide range of properties, including melting point. Principal interest at present lies in the formation of compounds suitable for coatings but various possibilities for food uses are also discussed. Butyrates and other esters may be used, although the properties of resultant inter-esters are not yet reported.

CONCLUSION

The authors realize that there are of necessity many omissions in this paper. They hope there are no serious ones. Except for the topics discussed in detail, only representative papers are cited. Some of these representative papers give typical data, others describe the development of methods and show their application, and still others are topic reviews with extensive bibliographies. To have included all others relating to the subjects would have increased the list of references by three- or fourfold—and needlessly so, since those interested in specific details on these points must necessarily go to the sources.

An attempt has been made to be reasonably critical in examining the matter presented, and, where conflicting views exist, to present both sides with as much analysis as seemed warranted. Particular attention has been given to pointing out where additional, and perhaps different, types of research are indicated, in the hope that workers in the field may be encouraged to investigate some of these problems. If this should be the result, this paper will have been worthwhile.

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REDUCTION OF THE FAT SEPARATION IN EVAPORATED MILK[1]

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Separation of fat is a defect that commonly develops during the storage of evaporated and other sterilized milks. The only solution has been a partial one—reducing separation by periodically inverting the containers. The problem is particularly acute in milk that is sterilized by the high-temperature short-time method, because of the lower viscosity of such milk. Even though high-temperature short-time sterilization is presently the most feasible method for improving the color and flavor of evaporated milk, the accompanying problem of fat separation delays general adoption of this processing method by the industry.

The phenomenon is more complex than a simple creaming: In addition to creaming—a progressive rise of fat globules to the top—there forms a sticky, tenacious layer, high in fat content, which cannot be satisfactorily dispersed by mixing upon prolonged storage. Some oiling off when the milk is warmed indicates a loss of stability of the fat emulsion, apparently from a partial denaturation and disruption of the protein material surrounding the fat globules. Preliminary observations indicate that destabilization of the fat emulsion is largely restricted to the very top (surface) layer, suggesting a surface denaturation of the stabilizing material around the fat globules. Surface denaturation, together with a deformation of the fat globules and disruption of the globule membranes brought about by packing pressure, may account also for a stickiness and tenacity of the surface layer that prevents its uniform dispersion upon mixing. Controlling the defect depends on preventing the rise of the fat globules.

Stokes' law, where $v = r^2 \frac{2g(d_1 - d_2)}{9\eta}$, gives the velocity of rise for spherical particles in a liquid. The rise of fat globules in milk plasma is in general agreement with Stokes' law *(1, 11, 15)*. Size of the fat globules (radius r), density difference between the fat globules and surrounding medium ($d_1 - d_2$), and viscosity (η) are the three primary factors involved in the control of fat separation in evaporated milk. [Clustering of fat globules *(1, 11, 15)* is probably unimportant, because the "agglutinin" is inactivated by heat or homogenization *(10, 12)*; clumping of fat globules *(3, 16)* is possible but can be controlled by two-stage homogenization.] The influence of the three primary factors has been demonstrated *(2, 9, 17, 18, 19)*.

The viscosity of evaporated milk can be increased by excessive heating in the sterilization procedure, but browning and cooked flavor also are increased. Tarassuk and Nury *(13)* demonstrated that optimum viscosity without adverse effects can be obtained by enzymatic treatment prior to sterilization.

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The effectiveness of homogenization is influenced by various factors. As has been recently pointed out by Dunkley and Brockmeyer *(4)*, "fundamental information regarding the mechanism of homogenization is incomplete. It is probable that future developments could make possible marked improvements in the process." Van Kreveld *(7)* showed how markedly the product varied with variations in homogenization technique. Ordinarily, about 30% of the fat cannot be detected through a microscope and is probably of submicroscopic size; at the other extreme, a considerable part of the fat is shown as larger fat globules in size-distribution curves of the fat globules. Even though ideal homogenization is not available in a single step, an improved product can be obtained by repeating homogenization or separating the large fat globules and rehomogenizing that portion. Kunick *(8)* patented the latter procedure for obtaining perfectly homogenized milk.

This study presents data on reducing fat separation in evaporated milk by controlling viscosity and the size of the fat globules.

MATERIALS AND METHODS

Evaporated milk in a commercial plant was taken off the conveyor before sterilization and immediately placed in ice water; the experiments were completed on the same day. Enzymatic treatment was done as described previously *(13)*, with incubation at 3° C. for 1 hour as a rule, sometimes at 37° C. for ½ hour.[2] Controls were run with all experiments. Immediately after incubation the milk was sterilized in a Fort Wayne batch sterilizer, with the reel continuously operating in the following manner:

a) Temperature raised to 224° F. as fast as possible (6 to 7 minutes).
b) Temperature then raised from 224° to 236° F. at the rate of 3° F. per minute.
c) Temperature raised from 236° to 243° F. as fast as possible (½ minute).
d) Cans held at 243° F. for 12½ minutes, then cooled in tap water in the sterilizer for 10 minutes.

The above method was found to be comparable in viscosity to sterilization in a commercial continuous sterilizer.

For homogenization and separation experiments, condensed milk was taken from a pipeline immediately before the can filler. The milk was rehomogenized at 140° F. in a Manton-Gaulin homogenizer with Super-Homo valve, at pressures of 2,000 and 500 p.s.i. for first and second stages, respectively. Separation of the condensed milk was at 100° F. in a De Laval separator, with the cream screw set for 25% cream under ordinary operation. The milks were immediately cooled in ice water after homogenization or separation, and cans were filled and sterilized as described above.

[2] Steapsin and pancreatin were obtained from Pfanstiehl Chemical Co., pepsin from Parke Davis Co., Tryptar from Armour Laboratories, Enzylac from American Sealkap Corp.

Homogenization (as above) before and after preheating was tried. For this experiment whole milk was obtained from the University Creamery and standardized to a ratio of fat to total solids of 0.306. Preheating was in a steam-jacketed vat under continuous vigorous agitation at 182° F. for ½ hour. One portion was homogenized after preheating; the other portion was heated instantaneously to 180° F. in a tubular heater, homogenized at 140° F., and then preheated at 182° F. for 30 minutes. Both portions of milk were then condensed at 120° F. in a Rogers vacuum pan to 8° Bé, cooled in ice water, and standardized to 26% T.S. Cans were filled and sterilized as described above.

Experimental samples were stored at room temperature for 6 months without inversion. Viscosity and fat content in the top portion were determined every 1 to 2 months. Viscosity determinations (after mixing the sample) were made with the Fisher Electroviscometer at 25° C. This viscometer is standardized to give values of viscosity in absolute units, i.e., centipoise, but it must be realized that the viscosity measured in these experiments is not absolute but apparent viscosity, since it includes both "basic" and "structural" viscosity of evaporated milk. For fat determinations, samples were frozen overnight at –22° C., approximately 90 g. of the top portion was cut off, and the fat was determined in 1:1 dilution by the Babcock method. It was then expressed as per cent "creaming" $= \frac{\text{fat content increase}}{\text{maximum fat content increase}} \times 100$. The maximum fat content increase (all the fat in the top portion) was simply calculated from the weight of the top portion, the total weight of the milk, and the original fat content. To determine the duplicability of the per cent creaming, as expressed in this paper, the fat in the top portion was determined in duplicate in 24 identical cans of stored evaporated milk and per cent creaming was calculated. The average per cent creaming was 14.5 with a standard deviation of 1.9.[3]

Size of the fat globules (homogenization effectiveness) was examined in the fresh samples microscopically with a Whipple micrometer disc, and homogenization effectiveness was expressed as a modified Farrall index *(5)*. Index 60 corresponded to U. S. Public Health Service "percentage difference" 10. The homogenization effectiveness was also examined by a rapid creaming test, centrifuging 50 ml. of evaporated milk in an International centrifuge (radius 18 cm. to the bottom of the tubes) at 25° C. and 2,500 r.p.m. for 15 minutes. A top portion of 10 ml. was then taken and the fat content, with that of the original milk, was determined by the Mojonnier method. Homogenization effectiveness, expressed as per cent creaming in centrifuged tubes, was calculated as above.

RESULTS AND DISCUSSION

Variation in untreated commercial samples. Commercial evaporated milks[4] were found to vary considerably, in both viscosity and homogenization effective-

[3] Data presented in this paper are based on the results from two or more cans. Conclusions drawn are based on the averages of large numbers of samples.

[4] Representative samples collected from one plant over a period of 1 year.

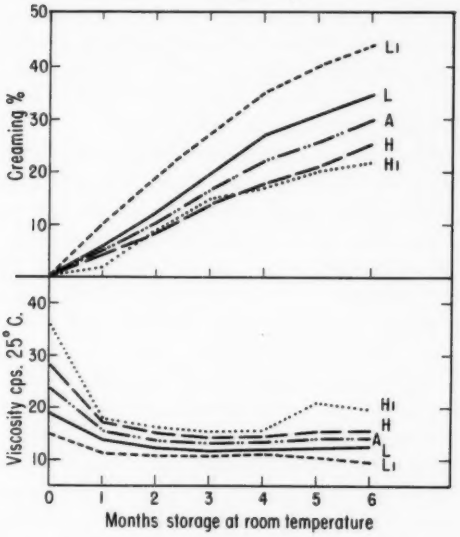

FIG. 1. Viscosity and creaming of commercial evaporated milk. A = av. of 17 milks (av. initial viscosity 23.9 cps.), Ll = sample with lowest initial viscosity, Hl = sample with highest initial viscosity, L = av. of 8 milks with initial viscosity below 23.9 cps., H = av. of 9 milks with initial viscosity over 23.9 cps.

ness. The course of viscosity changes and creaming during storage of untreated (control) samples and the effect of viscosity on creaming are presented in Figure 1. Curves A, representing the averages, show the general course. Viscosity decreased during the first 1 to 2 months (age thinning), then remained practically constant. The number of determinations was insufficient to establish the type of curve of viscosity decrease during age thinning. Maxcy and Sommer *(9)* obtained a logarithmic curve. Amount of creaming showed a fairly steady increase during storage, leveling off slightly toward the end of the storage period. The average globule diameter of the fat, calculated with Stokes' formula was 0.58 μ during the first month, and 0.49 μ (average) after that.[5] This indicates that large fat globules rise during the age-thinning period, their larger diameter and higher viscosity compensating during this period and yielding approximately the same rate of creaming throughout the storage period. The real average globule diameter of the fat in evaporated milk is higher (over 1 μ) than the calculated value above *(6, 7)*, therefore the average velocity of fat rise per month should have been greater than the observed velocity of 0.36 cm. To account

[5] The calculation was based on the following figures: velocity of fat rise per month 0.36 cm. (taking average creaming at 5% per month—Figure 1, creaming curve A—and height of the bottom layer at 7.2 cm. as measured from the cans), viscosity 19.8 cps. during the first month and 14.0 cps. later on (Figure 1, viscosity curve A), density of the fat 0.92 (assumed), density of the surrounding medium 1.07 (assumed).

for this difference, it must be assumed that there is an adsorption of material from the milk plasma on the fat globules. This would significantly increase the d_2 (density of the fat globules). The low value for the size of the fat globules as calculated by Stokes' law indicates that in fat separation of evaporated milk there is no clustering but a rise of single fat globules.

In Figure 1 the sample L1 with the lowest viscosity, by coincidence, had a high Farrall index (poor homogenization effectiveness). Because of the simultaneous effect of these two factors, curve L1 for creaming was found to be high above the average, A. The high viscosity of the sample H1 reduced creaming below average. Other samples, with lower viscosity than H1 but smaller fat globules, had creaming curves considerably below H1 (not drawn in Figure 1). This shows the importance of both factors, viscosity and size of the fat globules, for the creaming. In Figure 1, curves H represent the averages of the samples with high viscosity (initial viscosities[6] higher than the average initial viscosity of all the samples), and curves L represent the averages of the samples with low viscosity (initial viscosities below the total average). Both categories represent varying homogenization effectiveness. Therefore curves H and L demonstrate the effect of viscosity, eliminating the effect of size of the fat globules. The effect of viscosity on creaming in commercial samples was estimated by using L as a control, comparing the viscosity increase of H over L with the creaming decrease of H over L and expressing the values for H as a ratio to those for L. An increase of initial viscosity to 1.51 (28.4 for H over 18.8 for L) resulted in an increase of viscosity during storage (arithmetical average of the viscosity increases during the whole storage period) to 1.23 and a reduction of creaming to 0.7 (arithmetical average of the decreases in creaming during storage).

Control of the viscosity. The average effect of enzyme treatment is illustrated in Figure 2, and the effect of single enzymes and other treatments in Table 1, first section. Batches of treated evaporated milk and untreated control samples were stored and examined as described under *Materials and Methods.* Results were summarized in Table 1 by taking the values determined after 0, 3, and 6 months of storage and expressing these values as a ratio of the treated sample to the control. The magnitude of the ratio gives the effect of treatment and it is useful when working with Stokes' law. It is evident that to maintain a significantly higher viscosity than the control throughout the storage period, the initial viscosity has to be quite high—over 50 cps. This was impossible in some milks because of too-high grain, indicating that the maximum "conditioning" applicable varies with the colloidal properties of the milk.

According to Stokes' formula, viscosity and velocity of rise change inversely proportionally if the other factors remain constant. Theoretically, this means that the product of (increased) viscosity times (decreased) creaming of an experimental sample of evaporated milk over the untreated control sample should be 1 if both values are expressed as ratios to the control values and viscosity is the only factor involved (creaming and velocity of rise change in the same ratio). Actually, the product of viscosity × creaming, calculated in Table 1,

[6] Viscosity immediately after sterilization.

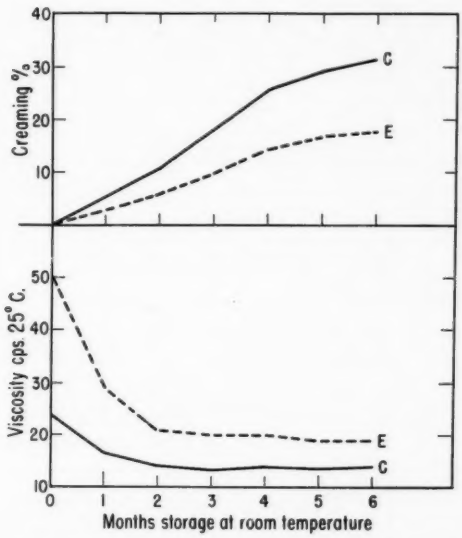

FIG. 2. Viscosity and creaming of commercial evaporated milk treated with enzymes. C = av. of 5 controls, E = av. of 5 enzyme treated milks (treatments were: 1.2 p.p.m. pepsin, 60.0 p.p.m. Enzylac, 2.75 p.p.m. Tryptar, 16.5 p.p.m. steapsin, 120.0 p.p.m. pancreatin. Incubation 1 hour at 3° C.).

should be below 1 because the greater difference in viscosity between treated and control samples during the age thinning period (Figure 2 and Table 1) was not taken into account. Instead, the calculated value was based on viscosity difference after 3 or 6 months. This effect is relatively greater after 3 months than after 6 months of storage, predicting a higher value for the product of viscosity × creaming in the latter case, but still below 1. Because of errors in fat and viscosity values determined after 3 or 6 months, the product of viscosity × creaming in Table 1 is not as predicted by the ideal. The regular determination error was enlarged—for viscosity, because of inhomogeneity in some samples produced by immiscible fat separation; for fat, because some of the "bottom milk" pressed through the solid top layer during the freezing of the cans.

In Table 1 the products of viscosity × creaming yielded by variations in the controls (untreated commercial samples) and by treating milks with some enzymes were in the predicted range. Milks treated with other enzymes showed significantly lower values for the product of viscosity × creaming (when treated with pepsin + palmitic acid, Enzylac, and Tryptar), and sometimes the product was lower after 6 months of storage than after 3 months. This indicates that the creaming decrease was due to more than the increase in viscosity; another factor, probably a greater weight of the fat globules, was working in the same direction. This density increase of the fat globules is probably caused by adsorption of material on their surface, which is supported by the fact that this has more effect on the small globules and shows up particularly after 6 months of storage, and

TABLE 1

Viscosity and creaming (expressed as fractions of the control values) of evaporated milk "conditioned" by enzymatic action or other treatments

Materials added or other differences between experiment and control	Fresh	3 months storage			6 months storage		
	Viscosity	Viscosity	Creaming	Visc. × creaming	Viscosity	Creaming	Visc. × creaming
Difference 9.6 in initial viscosity[a]	1.5	1.2	0.7	0.8	1.2	0.7	0.8
Pepsin 1.2 p.p.m.	2.4	1.5	0.7	1.1	1.3	0.6	0.8
Pepsin 0.7 p.p.m. + palmitic acid 0.1%[b]	2.5	1.6	0.3	0.5	1.4	0.4	0.6
Enzylac 60 p.p.m.	2.2	1.9	0.3	0.6	1.5	0.2	0.3
Tryptar 2.75 p.p.m.	2.3	1.6	0.6	1.0	1.4	0.4	0.6
Steapsin 16.5 p.p.m.	1.5	1.2	0.8	1.0	1.2	0.8	1.0
Steapsin 6.0 p.p.m. (37° C. incubation)	2.6	1.9	0.4	0.8	1.6	0.5	0.9
Pancreatin 120 p.p.m.	2.3	1.5	0.6	0.9	1.4	0.7	1.0
Pancreatin 40 p.p.m. (37° C. incubation)	2.8	1.6	0.4	0.6	1.6	0.6	1.0
Sn^{++} 50 p.p.m.[c]	2.5	1.8	0.1	0.2	1.6	0.7	1.1
Sn^{++++} 50 p.p.m.[c]	3.6	2.2	0.0	0.0	2.5	0.4	1.0
Homogenized before preheating	3.0	2.4	0.6	1.4	2.3	0.4	0.9
Difference 50 in Farrall index[a]	1.0	1.0	0.7	0.7	1.0	1.0	1.0
Extra homogenized once	1.0	1.0	0.8	0.8	1.0	0.7	0.7
Extra homogenized twice	1.0	1.0	0.7	0.7	1.0	0.5	0.5
Separated once	0.9	1.0	0.8	0.8	1.0	0.7	0.7
Separated three times	0.7	0.8	0.4	0.3	0.9	0.6	0.5

[a] Untreated commercial samples. This difference was taken from the variation of the controls.

[b] Palmitic acid (Eastman Kodak—Distillation Products) was added before sterilization in the melted state, without water at ca. 70° C.

[c] Added before sterilization as chlorides (Mallinckrodt Chemical Works).

also by the fact that milks that were treated with pepsin + palmitic acid or Enzylac showed marked improvement in miscibility of the cream layer. More surface material would probably decrease the tendency of the fat globules to flow together. The material adsorbed may be protein or fatty acid (Enzylac besides proteolytic enzyme also contains lipolytic enzyme). Tarassuk and Richardson *(14)* found that solid fatty acids highly affected rennet coagulation and curd tension, probably via adsorption on the caseinate complex. A similar adsorption may take place on the outer protein membrane of the fat globules. Addition of tin (Table 1) was particularly effective during the first half of the storage period. Homogenization before preheating increased the viscosity (reduced heat stability) but also caused a large increase in Farrall index and a marked amount of clustering or clumping of the fat globules, increasing the creaming. This explains the high product of viscosity × creaming obtained during the first 3 months of storage.

Treated milks of Table 1 usually showed a higher level of grain (film grain) and a flavor the same as the control. The reduction of fat separation in evaporated milk by means of increasing viscosity is limited because the average viscosity during storage can be increased only to a certain extent because of a rapid loss of viscosity during the first 2 months of storage. Control of the "age thinning" is imperative for further progress via the viscosity factor.

Variation in homogenization effectiveness in untreated commercial samples. Curves CS and CH in Figure 3 show the effect on creaming of variation in size

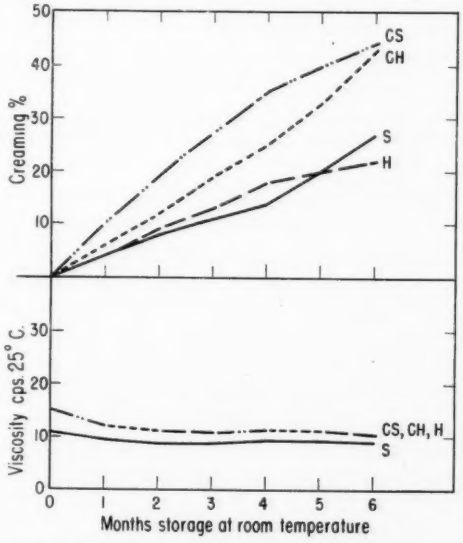

FIG. 3. Size of fat globules and creaming of commercial evaporated milk that is extra-homogenized or separated. CH = control with Farrall index 40, CS = control with Farrall index 90, H = CH triple homogenization, Farrall index 8, S = CS separated three times, Farrall index 8.

of fat globules due to variation in homogenization effectiveness of commercial samples. These curves represent two samples with the same viscosity, eliminating the effect of viscosity on the creaming. Farrall indices were 90 for sample CS (large fat globules) and 40 for sample CH (small fat globules). Using CS as a control and expressing the values for CH as a ratio to those for CS, the difference of 50 in Farrall index caused a reduction of the creaming to 0.7 (arithmetical average of the decreases in creaming during storage).

Control of the size of the fat globules. Extra homogenization or separation of the larger fat globules reduced creaming considerably (Table 1, section 2, and Figure 3) via the reduced size of the fat globules. This method is attractive because the velocity of rise decreases with the square of the globule radius in Stokes' formula. Milk of Farrall index 40 was improved to index 12 by one extra homogenization and to index 8 by an additional homogenization. This shows that satisfactorily homogenized milk (Farrall index below 60) can be improved considerably by rehomogenization. Values given by rapid-creaming tests were 0.86 and 0.55 for the milk given one and two extra homogenizations, respectively, as compared with a value of 1 for the control. Milk of Farrall index 90 (fat percentage 7.9) was improved by separation once, twice, and three times to Farrall indices 17, 12, and 8, respectively (fat percentages 6.6, 5.8, and 5.3, respectively). Farrall indices of the successive "creams" removed were 1064, 737, and 289, respectively (fat percentages 20.6, 13.9, and 11.2, respectively). This indicates that even when milk has not been homogenized satisfactorily (Farrall index above 60), it can be improved greatly by separation of the large globules. Values given by rapid-creaming tests were 0.59 and 0.37 after separation once and three times, respectively.

The maximum homogenization effectiveness obtained reduced the creaming to ca. 0.5. According to Stokes' law, this means a relatively small reduction in the average size of the fat globules, to ca. 0.7 in this case (square root from 0.5, if no other factors are involved).

These data, as expected, showed that maximum homogenization effectiveness is important and stress the need for future developments in homogenization that may eliminate the fat separation in evaporated milk. Separation and rehomogenization of the larger fat globules can be applied for improvement beyond the limits of the present homogenization effectiveness. Commercial realization of this can be tried by placing a separator in the milk line behind the homogenizer and leading the "cream" back into the line in front of the homogenizer. Better homogenization effectiveness by the use of high homogenization pressure could be the answer for high-temperature short-time sterilized evaporated milk. In this case the lowering of heat stability due to high homogenization pressure is not critical as it would be with conventional sterilization (243° F. 14 minutes).

SUMMARY AND CONCLUSIONS

Evaporated milk during storage for 6 months at room temperature without turning over the cans showed a decrease in viscosity during the first 2 months but practically no decrease after that. The fat separation was fairly steady:

About 5% of the fat per month rose to the top portion. The creaming could be explained as a rise of single fat globules. Commercial evaporated milk varied considerably in viscosity and homogenization effectiveness. Viscosity and creaming varied in about the same ratio as predicted by Stokes' formula.

Enzymatic treatment before sterilization increased average viscosity during storage to about 1.5, with reduction in creaming to ca. 0.5. Some enzymes produced more creaming decrease than was accounted for by viscosity increase. This probably was caused by material adsorbed on the surface of the fat globules. The application of enzymes was limited by heat stability of the milk.

Increased homogenization effectiveness obtained by rehomogenization or separation of the larger fat globules was found to reduce creaming to about one-half that of the controls.

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STUDIES ON THE COLLOIDAL PROTEINS OF SKIMMILK. I. THE EFFECT OF HEAT AND CERTAIN SALTS ON THE CENTRIFUGAL SEDIMENTATION OF MILK PROTEINS[1]

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The heat stability of evaporated milk depends primarily on the stability of the calcium caseinate–calcium phosphate system. The optimum degree of heat stability requires proper preheating of the fluid milk and the addition before sterilization of stabilizing salts, e.g., disodium phosphate. Sommer and Hart *(9)* established the importance of the "salt-balance," or ionic equilibria, to the heat stability of milk. Webb and Holm *(11)* studied the effect of various salts on the stability of different types of milks. Most milks were found to require the addition of polyvalent negative ions (phosphate or citrate) in order to increase their stability during sterilization. Other workers have shown that the analytical composition of milk bears no relation to its heat stability *(3)*. Extensive studies have been made with respect to the beneficial effect of preheating the whole milk on the heat stability of the concentrated product. However, the physical and chemical changes brought about by either treatment are little understood.

The coagulation or gelation of colloidal systems is the result of the interaction, or aggregation, of the dispersed component to form a rigid system. Casein exists in normal milk as aggregates, which are composed of calcium caseinate and calcium phosphate, in varying degrees of dispersion. However, these aggregates, or micelles, are quite stable in normal milk: Coagulation requires about 12 hours at 212° F. This does not mean that changes in the state and average size of the aggregates do not occur. The sizes of the micelles have been reported to range from 5 to 200 mμ in diameter *(5, 12)*. Ford and Ramsdell *(2)* used a centrifugal method of studying the sizes of the casein complex. They observed a minimum particle size of diameter 64 mμ and concluded that the number of different sizes is limited. Two size ranges were noted, each occurring in multiples of a unit size. Different milk samples varied widely in the distribution of sizes.

The degree of dispersion is the result of the over-all ionic equilibria in the milk. The addition of stabilizing salts and the use of preheating treatments undoubtedly affect this eqilibria. The changes brought about by these treatments are not readily observable, except that considerable variations occur in the resistance of differently treated milks to heat coagulation.

This study was conducted to determine what effects on the centrifugal sedimentation rates of milk proteins would be produced by heating skimmilk to

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[1] The data are part of a thesis presented to the Graduate School of the University of California by the senior author in partial fulfillment of the requirements for the degree of Doctor of Philosophy, June, 1954.

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preheating temperatures and by adding disodium phosphate and calcium chloride. This method affords a means of observing small physical and chemical changes in the colloidal particles. The effects of these treatments on the chemical composition of the sedimenting material are presented in the second paper on this general subject.

EXPERIMENTAL PROCEDURE

Preparation of sample. Fresh whole milk was separated twice in a cream separator immediately after receiving, yielding a fat content of less than 0.1% as determined by the Mojonnier method. In most of the experiments the variations in sample treatments included a raw skim control sample, a heated sample, and samples, with and without heating, containing different amounts of Na_2HPO_4 or $CaCl_2$. The heating was done at 88° C. for 15 minutes, with stirring, in 1-l. flasks fitted with stoppers so as to minimize evaporation. Total solids analysis indicated no significant loss from evaporation. The Na_2HPO_4 was added in dry form while stirring before heating, but the $CaCl_2$ was added as a solution in order to prevent its localized precipitating effect.

Centrifugation—depletion method. The technique described below is similar to the one used by Ford and Ramsdell *(2)*. A Spinco Model L centrifuge with evacuated, refrigerated rotor chamber was used for the depletion studies. It was possible to maintain a temperature of 20° ± 1° C. throughout runs of several minutes duration. The rotor used accommodated 12 lusteroid tubes of 13.5-ml. capacity each. The tubes were fitted with caps to prevent evaporation and collapsing of the tubes during the runs. An automatic speed control and revolution counter, together with acceleration and deceleration data, afforded an accurate means of calculating the equivalent centrifuging time at 20,000 r.p.m. This is equivalent to a force of 26,000 times gravity.

The lusteroid tubes were filled so that the upper level was 1.0 cm. from the top of the tube. After the centrifuging, the supernatant serum was carefully siphoned off from the bottom of the tube to a level of 1.2 cm. The dimensions of the rotor are such that these values place the inner meniscus at 4.6 cm. and the lower level at 7.4 cm. from the rotor axis during centrifugation. Thus, the particles moved through a maximum radial distance of 2.8 cm.

By using two or three centrifuge tubes for each sample, as many as four to six differently treated samples were centrifuged at one time, yielding from 20 to 30 ml. of supernatant liquid for each sample. The samples were centrifuged for successively increasing periods of time, the longer periods of centrifugation resulting in the removal of from 60 to 75% of the total nitrogen. The supernatant liquids were analyzed for total nitrogen, total calcium, total phosphorus, and in some cases for noncasein nitrogen. Densities and viscosities also were determined on some of the samples.

Analyses. A combination macro-digestion and semi-micro-distillation procedure was used for the total nitrogen and the Rowland *(8)* procedure for noncasein nitrogen. Viscosity measurements were made with an Ostwald type of viscosimeter at 20° C.

RESULTS AND DISCUSSION

Because of several complex changes brought about by heating and the addition of salts to milk, no attempt was made to measure definite particle sizes or quantitative changes in the size distribution of the casein complex. Such measurements depend on changes in serum viscosity brought about by heating, hydration of the particles, changes in shape and density of the particles. The possibility of an interaction between the caseinate fraction and heat-denatured serum proteins also complicates the picture. A quantitative determination of the effect of each of these factors is practically impossible. However, the relative rates of sedimentation do reveal significant differences.

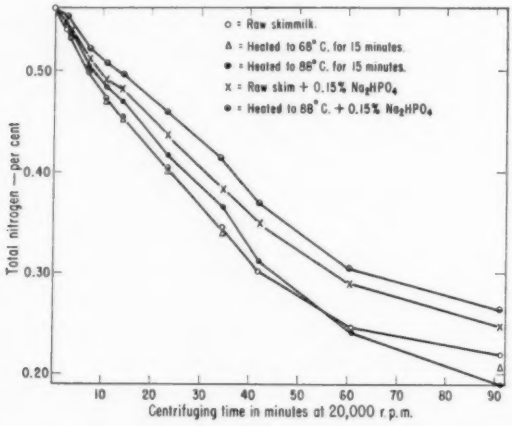

FIG. 1. The effect of heat and of the addition of disodium phosphate on the rate of total nitrogen sedimentation in skimmilk.

Figure 1 shows the effects on rate of nitrogen depletion that are induced by heat and the addition of 0.15% Na_2HPO_4 to raw and heated milks. A temperature of 68° C. for 15 minutes had no significant effect on sedimentation rate, whereas 88° C. for 15 minutes resulted in a decreased rate during the first part of the centrifuging run, which is in agreement with Ramsdell and Hufnagel's data *(6)*. However, after about 1 hour of centrifuging, the total amount of nitrogen sedimented in the heated sample was greater than in the raw sample. This reversal of difference showed the same general pattern in several other samples treated similarly.

The addition of 0.15% Na_2HPO_4 to the raw milk resulted in a marked decrease in the nitrogen sedimentation rate. This decrease was further enhanced by adding Na_2HPO_4 to the heated sample. A decrease in sedimentation rate due to heat alone was attributed by Ramsdell and Hufnagel to a decrease in the particle size of the casein complex. The decrease caused by the addition of Na_2HPO_4 is undoubtedly partly due to a shift toward a smaller average particle

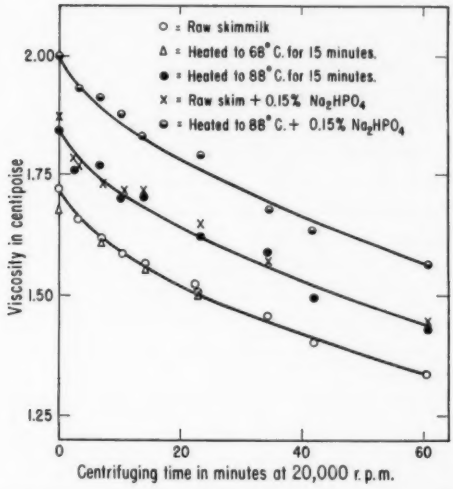

FIG. 2. The effect of heat and of the addition of disodium phosphate on the viscosity of skimmilk and the supernatant liquids obtained by centrifuging for different lengths of time.

size, but viscosity measurements on the supernatant liquids show that this explanation is inadequate (Figure 2). No significant change in the viscosities of the skimmilk or the supernatant liquids resulted from heating to 68° C. for 15 minutes. However, the viscosities of the skimmilk and supernatant liquids were considerably increased both by heating to 88° C. for 15 minutes and by adding Na_2HPO_4. The effect appears to be additive. However, it does not necessarily follow that the decreases in sedimentation rates caused by both heat and Na_2HPO_4 are additive. This is borne out by comparing the viscosity change during centrifugation for the heated sample with that of the raw sample containing 0.15% Na_2HPO_4, and also by the differences in sedimentation rates between these two samples. The viscosities of the supernatant liquids remained about the same (middle curve, Figure 2) for both samples, whereas the difference in sedimentation rates became increasingly greater as the centrifuging time was increased (Figure 1). By heating to 88° C., about 95% of the serum proteins are denatured, whereas little or no effect on the serum proteins would be expected by the addition of this quantity of Na_2HPO_4.

Other factors being equal, e.g., particle size distribution, density of the particles and medium, and shape of the particles, the amount of the substance sedimenting in any given time is inversely proportional to the viscosity, i.e., $\frac{x_1}{x_2} = \frac{n_2}{n_1}$ where x_1 and x_2 are the amounts of nitrogen removed and n_1 and n_2 are the solvent viscosities, respectively. The serum viscosities, obtained after removal of most of the caseinate, may be used for a close approximation. The application of this equation to the data for the raw (control) and the heated (88° C.) samples shows that for centrifuging periods of less than 40 minutes,

the increased viscosity due to heating was approximately sufficient to account for the decrease in sedimentation. However, this relationship becomes increasingly less applicable with longer centrifuging times, which shows that factors other than an increase in serum viscosity must be considered. It is not a simple matter to interpret the results in terms of changes in viscosity and size distribution. A shift of the calcium caseinate complex to an average smaller particle size probably accounted for most of the decreased nitrogen sedimentation rate when Na_2HPO_4 was added to raw milk. Again, it must not be assumed that the decrease in sedimentation rate brought about by the addition of this salt is due simply to an increase in viscosity and a decrease in particle size. Eilers *(1)* has pointed out that phosphate and citrate salts cause an increase in the hydration of casein. This would result in a decrease in the density of the particles but would tend to increase the particle size, so that the complete explanation becomes very complex.

Since heating to 88° C. for 15 minutes, without phosphate, caused a reversal in the sedimentation rate after about 40 minutes, when compared to the raw sample, and, since the viscosity remained higher throughout the run, the possibility of some of the heat-denatured proteins being removed in the centrifuge must be considered. A quantitative method of analyzing for the heat-denatured whey proteins is needed for this type of investigation to distinguish them from the casein fraction. The present methods distinguish between the two by the difference in the acid precipitable nitrogen of heated and raw samples. In this investigation the heated samples were also centrifuged, so a raw control sample containing the same amount of casein as the heated sample was not available for obtaining the serum protein content by difference.

The fact that the viscosity of the heated sample (88° C.) remained proportionately higher throughout the run indicates that nonsedimenting constituents, probably heat-labile serum proteins, were primarily responsible for the increase in viscosity when no phosphate was added.

In connection with these experiments it is interesting to note that a small amount of the casein remained in the supernatant fluid even after prolonged centrifugation, as shown in Figure 1. By using the particle density data given by Ford and Ramsdell *(2)* for the solvated particles, 90 minutes of centrifugation at the speed used in these experiments was calculated to be sufficient to remove the smallest particle (64 mμ in diameter) observed by them from the liquid portion used for analysis. It is uncertain whether residual casein was the result of convection in the angle centrifuge or particles smaller than 64 mμ in diameter. The percentage of the caseinate complex removed under any given conditions varies widely with different milks. The data for a 30-minute centrifuging time of four different raw milks are tabulated below. The values for the first two samples were taken from the results shown in Figures 1 and 5, respectively. These data show that wide variations occur in the size distribution of the complex.

The effect of adding $CaCl_2$ to raw skimmilk on the nitrogen sedimentation rate is shown graphically in Figure 3. A 5% solution was chosen as the form of adding the salt so that the results could be compared with the effect of similar

Source of milk	Casein nitrogen content of original skimmilk	Amount removed during 30 minutes of centrifuging
	(%)	*(%)*
Mixed herd milk	0.415	46.8
Individual Holstein	0.450	85.0
Individual Jersey	0.590	60.0
Individual Jersey	0.498	82.3

concentrations on the heat stability of skimmilks, which has been previously observed by Tarassuk and Cole *(10)*. The dilution was kept constant by adding appropriate quantities of distilled water. The amounts of the $CaCl_2$ solution included 0, 0.1, 0.8, and 2.0 ml. per 5 ml. of skimmilk. The smallest quantity (0.1 ml.) is equivalent to about one-third more calcium than is normally found in skimmilk. An undiluted skimmilk sample also was included (curve A, Figure 3), which obviously cannot be compared directly with the other samples.

Tarassuk and Cole observed that a marked decrease in the temperature of coagulation of skimmilk resulted from additions of $CaCl_2$ up to about 0.8 ml. of a 5.0% solution per 5 ml. of milk, after which a slight increase in the coagulation temperature occurred. A correlation of this observation with the results in

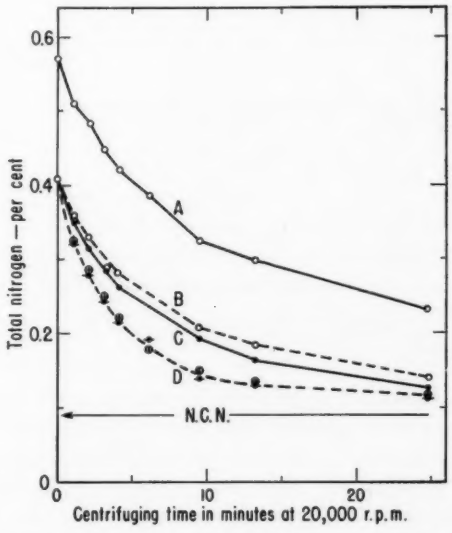

FIG. 3. The effect of adding $CaCl_2$ to raw skimmilk on the rate of total nitrogen sedimentation

Curve A — Undiluted skimmilk.
Curve B — Diluted, 2.0 ml. of water per 5.0 ml. of milk.
Curve C — Diluted, 0.1 ml. of 5.0% $CaCl_2$ per 5.0 ml. of milk.
Curve D — { Diluted, 0.8 ml. of 5.0% $CaCl_2$ per 5.0 ml. of milk.
{ Diluted, 2.0 ml. of 5.0% $CaCl_2$ per 5.0 ml. of milk.

Figure 3 can be seen. The nitrogen sedimentation rate was increased significantly by adding 0.1 ml. of $CaCl_2$ solution (curve C) when compared to the control sample (curve B). A more marked increase resulted from the addition of 0.8 ml. (curve D), but the addition of 2.0 ml. resulted in no further change (also curve D). It appears probable that a maximum average size of the caseinate complex was reached when the normal calcium concentration was increased approximately threefold.

Sedimentation of serum proteins. In another experiment, analyses for nonacid-precipitable nitrogen of the supernatant liquids of raw and heated skimmilk were made in addition to total nitrogen. Figure 4 shows the depletion of nonacid-precipitable nitrogen in the centrifuge. The noncasein nitrogen of the raw milk

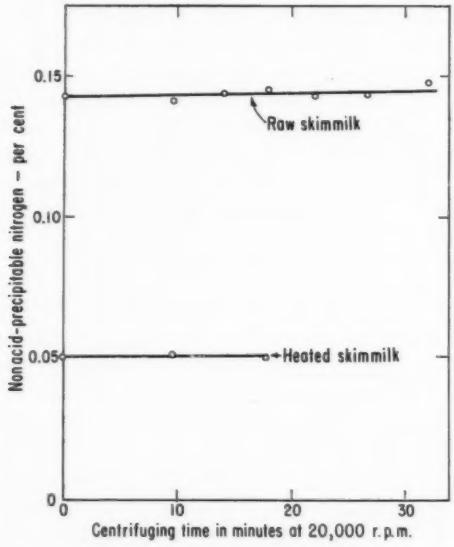

FIG. 4. The effect of centrifuging on the sedimentation of the nonacid-precipitable nitrogen in raw and heated skimmilk.

remained constant at about 0.142% for centrifuging times of more than 30 minutes. It is concluded from these data that an association between the casein and serum proteins does not occur in raw milk. The nonacid-precipitable nitrogen in the heated supernatant liquid also remained constant at about 0.050%. The difference between the two values, 0.092, represents the percentage of heat-labile serum protein nitrogen. By a similar procedure, although using a different method of plotting, Ramsdell and Whittier *(7)* concluded that this constant difference indicated that the heat-denatured serum proteins are not removed by centrifuging under conditions that are adequate for throwing out the casein complex. However, this difference will remain constant regardless of whether the heat-denatured proteins are removed by centrifugation or by acid precipi-

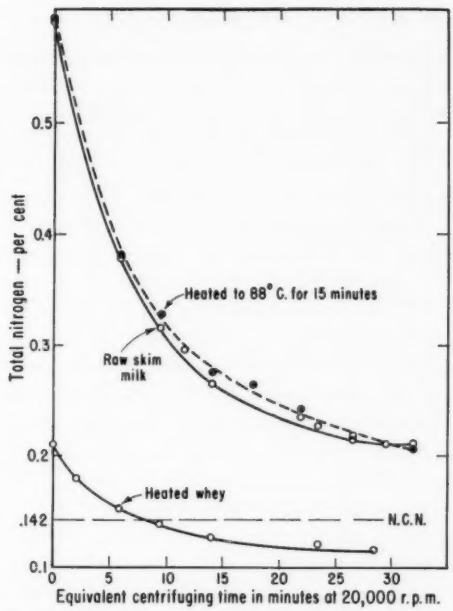

FIG. 5. Depletion of total nitrogen from raw and heated skimmilks, and heated whey with increasing centrifuging time.

tation. The analytical result will be the same. The available methods of analyzing for heat-denatured serum proteins are not capable of determining whether or not they are removed by centrifuging unless the total amount of sedimentable nitrogen exceeds the casein nitrogen content.

The depletion data for total nitrogen of the samples previously discussed are shown in Figure 5. Included are the data for a heated whey sample. The whey was obtained from the same lot of raw skimmilk by removing most (about 85%) of the casein in a high-speed centrifuge and then heating the whey to 88° C. for 15 minutes. The heated whey was then centrifuged for increasing periods of time along with the raw and heated skimmilks. The amount of total nitrogen remaining after nearly 30 minutes was 0.113%. This is 0.029% (0.142-0.113) below the noncasein nitrogen content. This figure represents the removal of about one-third (0.029/0.092) of the heat-denatured serum proteins. If some of the residual casein-nitrogen in this whey sample was not removed subsequent to heating, then an even greater quantity of heat-denatured serum protein nitrogen was thrown out with the caseinate complex. These results are not necessarily an indication of the changes occurring in the serum proteins when heated in the presence of the normal amount of casein. However, they are in line with the results obtained by McGugan *et al. (4)*. They showed by electrophoretic mobility studies that α-casein and β-lactoglobulin formed a stable complex when heated to 85° C. for 30 minutes.

SUMMARY

The effects of heating and of adding disodium phosphate and calcium chloride on the centrifugal sedimentation of the calcium caseinate complex in skimmilk were studied. An average centrifugal force of 26,000 times gravity was used. Portions of each lot of milk were centrifuged for successively increasing periods of time. Nitrogen depletion was followed by analyzing the original skimmilk and the supernatant liquids for total nitrogen and noncasein nitrogen.

Heating to 88° C. caused a decrease in the rate of total nitrogen sedimentation up to centrifuging times of about 40 minutes when compared to the raw milk sample, but a reversal of this difference occurred on prolonged centrifugation. The initial difference is accounted for by an increase in viscosity as a result of heating. The reversal, however, shows that the changes are more complex than simply an increase in the viscosity. A shift in the size distribution of the caseinate complex and the sedimentation of part of the heat-denatured serum proteins may take place as a result of heating. The addition of 0.15% disodium phosphate to raw skimmilk resulted in a marked decrease in the caseinate sedimentation rate. About 40% of this difference is accounted for by an increase in viscosity, but the remainder must be the result of a shift toward an average smaller particle size or to an increase in the degree of hydration. Heating to 88° C. for 15 minutes in combination with added phosphate caused a further decrease in the rate of sedimentation and also a pronounced increase in the viscosity. The increase in viscosity appears to be the result of an additive effect of the combination. Increasing rates of nitrogen depletion from the supernatant liquid resulted when the calcium content of raw milk was increased up to threefold by the addition of calcium chloride, but no further change resulted from increasing the calcium content up to sixfold.

The whey proteins of raw milk were found to be unaffected by the applied centrifugal force. Experiments with heated whey samples indicate that part of the heat-denatured whey proteins are removed with the caseinate complex.

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A RAPID SILICA GEL METHOD FOR MEASURING TOTAL FREE FATTY ACIDS IN MILK[1,2]

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Analyses for free fatty acids resulting from lipolytic activity in milk have been, in general, either too time consuming or inaccurate, or both. In the past, considerable attention has been given to methods involving solvent extraction of the fat and free fatty acids followed by titration of the extract. The main disadvantage of these methods is that the water-soluble fatty acids are only partially recovered *(1, 3, 5)*. More recently, chromatographic analyses have been applied to measure the total free fatty acids in saponified milk fat *(2, 4)*. These techniques have shown promise of meeting the requisites of the routine analyst, i.e., they are quantitative, sensitive, and relatively rapid. However, little attention has been given to the possibility of utilizing an inert support, such as silica gel, for the rapid separation of relatively small quantities of free fatty acids from milk, such as may be produced by lipolysis.

This report describes a method for the rapid, quantitative recovery of small amounts of free fatty acids from milk and cream by directly separating the acids from the product without prior fractionation.

PROCEDURE

The procedure of Harper and Armstrong *(2)* for the determination of butyric acid and higher fatty acids was modified so that the total quantity of free fatty acids could be recovered in one fraction and with one solvent in approximately 15 minutes, instead of 60 minutes as required with the original method. This modified method is outlined briefly below. The reader is referred to the original paper for a more detailed description of equipment and reagents.

A. *Equipment.* A chromatographic column approximately 35 mm. I.D. by 250 mm. in length and with a perforated glass disc sealed into a 34/23 standard-taper joint is utilized; the column is attached to a suction flask.

B. The silica gel column is prepared in two sections; the bottom section contains a mixture of silicic acid and phosphate buffer, and the top section contains the acidified milk and silicic acid.

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[2] Technical Paper 12-54, Department of Dairy Technology, The Ohio State University, Columbus. Ohio Agr. Expt. Sta. Journal Article No. 35-55.

[3] Ohio Agricultural Experiment Station, Wooster.

[4] The Ohio State University.

1. *Bottom section.* Five g. of dry silicic acid (Mallinckrodt No. 2847) are mixed thoroughly with 3 ml. of 2 *M* KH_2PO_4-K_2HPO_4 buffer (pH 6.5) and slurried with 20 ml. U.S.P. chloroform. A stock suspension of the above ingredients may be prepared at one time and stored in a tightly stoppered brown bottle. Twenty-five ml. of the well shaken suspension is used for each analysis.

2. *Top Section.* A sample of milk is pipetted (or weighed) into a mortar and is acidified to pH 1.8-2.0 (predetermined) with 20% H_2SO_4 (V:V). Five g. of silicic acid is then added for every 3 ml. of milk. The size of the sample will depend on its content of fat, total solids, and free fatty acids. Up to 20 ml. of milk may be used. After the addition of silicic acid, the mixture is ground thoroughly, slurried with 5% *n*-butanol in chloroform, and transferred quantitatively on top of the bottom section. A small wad of cotton is stuffed tightly into the exit end of the column just prior to addition of the top section. The cotton serves to retain any silicic acid particles which may pass through with the eluant.

C. *Sample size.* The sample size may be varied from 5 to 20 g., depending on the fat content and nature of the sample. With fresh milk it is necessary to use at least 10 g. in order to minimize errors in analysis.

D. *Extraction procedure.* The column is attached to a suction flask and a vacuum is applied so that the solvent will flow through the column at the rate of about 50 ml. per 2 minutes. The extraction is completed when 150 ml. of the 5% butanol in chloroform solvent have been collected.

E. *Estimation of acids.* The acids in the eluate are titrated as previously described *(2)*, except that 15 ml. of neutral absolute alcohol and 0.3 ml. of the phenol red indicator are used. A 50/50 (V:V) mixture of either ethyl ether and absolute ethanol or ethyl ether and isopropyl alcohol may be used to replace the absolute ethanol *(7)*. A photometer may be used to standardize the end-point. The results are expressed in terms of acid degree, i.e., ml. N base necessary to neutralize 100 g. fat.

EXPERIMENTAL RESULTS AND DISCUSSION

The reliability of the method was established by determining the recovery of known acids (butyric, caproic, capric, lauric, palmitic, and oleic) added individually to milk prior to acidification. Four trials were made in which the concentration of added acids was 10, 20, 40, and 60 microequivalents. The concentration of acid had no effect on the recovery. The results are summarized in Table 1. All the acids were quantitatively recovered; the poorest recovery occurred for palmitic acid, 90% of which was recovered.

The reproducibility of the method is illustrated in Table 2 for five replicate analyses of six different samples. The maximum deviation from the mean for any given sample was from 4.3 to 10.1%; and the average deviation from the mean was from 1.5 to 5.9%. The average maximum deviation was 7.6% and the average of the mean deviation was $\pm 4.05\%$.

TABLE 1

Reliability of the silica gel extraction method for the recovery of various fatty acids added to milk[a]

Acid	Per cent recovery		Average deviation from mean
	Range	Average	
Butyric	95-106	99.0	± 3.5 per cent
Caproic	96-104	100.0	± 4.0 per cent
Capric	92-94	93.0	± 1.0 per cent
Laurie	92-101	94.0	± 4.6 per cent
Palmitic	88-93	90.0	± 2.0 per cent
Oleic	92-98	96.0	± 3.0 per cent

[a] The percentage recovery of each acid is based on four replicate trials.

The silica gel extraction method was compared with the chromatographic method of Harper and Armstrong *(2)*. In order to obtain sufficient concentration of free acids in fresh milk without using large volumes for analysis with the silica gel method, 20 ml. of milk was neutralized and lyophilized prior to analysis. The freeze drying did not influence the results of the analyses. During

TABLE 2

Reproducibility of silica gel extraction method with milks of different acid degrees

Sample No.	Acid degree range	Average acid degree[a]	Per cent deviation from average acid degree		
			Minimum	Maximum	Average
1	0.60- 0.75	0.67	1.1	10.1	±5.9
2	1.22- 1.34	1.26	0.0	6.3	±1.5
3	1.85- 2.20	2.00	2.5	10.0	±4.5
4	2.45- 2.80	2.60	1.6	7.5	±5.5
5	4.50- 4.90	4.71	0.3	4.3	±3.6
6	13.70-15.00	14.80	0.9	7.4	±3.3
Average				7.6	±4.05

[a] Average of five trials.

the study, 40 samples varying in acid degree values from 0.51 to 6.0 were analyzed. The results are presented in Table 3. The data are grouped in four different acid degree ranges in order to determine the applicability of the method for samples of widely varying free fatty acid content. The results show that the silica gel extraction method gave results comparable to the chromatographic

TABLE 3

Comparison of the silica gel extraction method and the chromatographic method

Acid degree range	No. of samples	Per cent variation for mean acid degree value[a]		
		Minimum	Maximum	Mean
0.5-1.0	9	8.1	7.6	±3.7
1.1-2.0	12	9.3	10.9	±4.6
2.1-3.0	8	5.3	8.6	±5.1
3.0-6.0	10	7.3	9.2	±4.8
Average		9.3	10.9	±4.6

[a] Acid degree values by the silica gel extraction method compared to average acid degree values obtained by chromatographic method of Harper and Armstrong *(2)*.

method. The average deviation from the mean was within the experimental error of the longer method *(2)*.

The silica gel extraction method was also compared with the solvent extraction method of Johnson and Gould *(3)* as modified by Thomas *et al. (6)*. Twenty-six samples, which varied in acid degree values from 0.37 to 7.0, were analyzed in duplicate by each method. The average acid degree values are compared in Table 4. The data are divided into two groups, the samples with

TABLE 4

Comparison of the silica gel extraction method with the solvent extraction method

Acid degree values			
Solvent extraction	Silica gel extraction	Solvent extraction	Silica gel extraction
0.37	0.39	1.50	1.55
0.70	0.68	1.87	1.88
0.92	0.98	1.82	2.10
0.94	0.94	1.92	2.15
0.94	0.96	2.12	2.30
1.02	0.91	2.20	2.22
1.05	0.95	2.20	2.35
1.07	1.01	2.35	2.50
1.19	0.94	2.98	3.05
1.13	1.18	3.64	3.87
1.22	1.28	3.80	4.10
1.25	1.20	4.40	4.61
1.34	1.40	6.70	7.05

acid degrees of less than 1.5 and those with 1.5 or more. For samples with acid degrees of less than 1.5, the values obtained by the two methods were in very good agreement. However, for samples with acid degree values greater than 1.5, the silica gel extraction method gave slightly higher values. This is especially true for all samples with an acid degree value of over 2.3, for which the silica gel method gave results that are consistently about 5% higher than those obtained by solvent extraction. The difference in the two methods is thought to be related to the better recovery of the lower fatty acids by the silica gel extraction method.

SUMMARY

A silica gel extraction procedure is described for determining the total free fatty acids in milk without prior extraction of the fat. The method is rapid and provides quantitative recovery of the free fatty acids in milk. It requires only 15 minutes instead of about 60 minutes as required in previous methods. The method is more quantitative in respect to the recovery of free fatty acids than any of the previous methods used for the measurement of free fatty acids in milk. However, in samples of acid degrees of less than 1.5 the results obtained by the silica gel extraction method are comparable to those obtained by the solvent extraction method and the chromatographic method. With acid degrees higher than 1.5 the silica gel extraction method generally reveals a higher free fatty acid content.

Preliminary results also indicate that the solvent extraction method is applicable to the analysis of other dairy products, such as dry milk, condensed milk, ice cream mix, and butter.

To minimize the expense of reagents, freeze-dried samples may be used if desired.

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THE CONCEPT OF FRUCTOSE UTILIZATION BY BULL SPERM AND ITS RELATION TO FERTILITY[1]

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Metabolic activity of spermatozoa is chiefly expressed by two processes, namely, respiration and glycolysis. The rates of both are governed by concentration and motility of sperm. Chang and Walton *(3)* showed that a significant relationship exists between respiratory and motile activity of sperm. Similarly, glycolysis and motility appear to be closely correlated, according to Comstock *(4)*. Since it has been found that the fertilizing capacity of semen is dependent on the degree of metabolic activity of sperm *(3, 15)*, it seems logical that either motility or fructolysis should show a good correlation with fertility. Therefore a measure of the rate of fructolysis as expressed by a "fructolysis index," should offer a useful instrument for predicting fertility of a semen sample.

Even before Mann *(14)* found that the major carbohydrate component of seminal plasma was fructose and not glucose as heretofore assumed, glycolysis and/or lactic acid production were used as criteria for semen evaluation by numerous investigators *(4, 5, 11, 12, 16, 18)*. After the identification of fructose, it was shown that its removal is positively correlated with the concentration of motile spermatozoa *(1, 2, 10)*. Highly significant correlations between the "fructolysis index" (milligrams fructose removed in 1, 2, or 3 hours by 10^9 sperm) and breeding efficiency on a between-bull basis have been shown by Gassner and coworkers *(6, 7, 8, 10)* in three successive years. The results were: for 1950, 0.832 ± 0.082; for 1951, 0.80 ± 0.21; and for 1952, 0.77 ± 0.153. Although Sechrist *(19)* found a positive correlation of 0.59 between the fructose used in 1 hour and nonreturns, it lacked significance. However in multiple correlation, the initial fructose level, the amount of fructose used in 1 hour, and the nonreturns were highly significant. Bishop *et al. (2)* found a relationship between metabolic tests (methylene-blue reduction and fructolysis per milliliter semen) and fertility after discarding the data from one of four centers tested. Recognition was given to the possibility that the relationship of metabolic tests to fertility may be affected by the degree of dilution.

Since practical application of the fructolysis test seems to be beset with certain difficulties, it appears pertinent to examine briefly the physiologic relationship of testis–accessory sex organ function to semen metabolism.

Fructose has been shown to be a normal constituent of semen *(15)*. It is the sole carbohydrate present in the seminal plasma of the bull *(9)*. It is produced principally by the seminal vesicles and to a lesser extent by the ampullae vasa deferentia. It has been further demonstrated that the rate of synthesis of fructose is under specific hormonal control of the testis and therefore a func-

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tional indicator of the Leydig cell system of the testis. On the other hand, spermatogenesis, although also under specific but quite different hormonal regulation, is a separate process which bears no relationship to accessory sex organ function and is therefore independent of fructose synthesis *(6, 9, 15)*. In fact, since neither the testis nor the epididymal sperm contain fructose, the still immotile spermatozoa come in contact with seminal fructose only after being intermixed with seminal plasma during ejaculation. This happens at a crucial moment when the sperm must attain a high degree of motility and require a source of quickly available energy. Hence, motile sperm are required for fructolysis. Because of the independence of these two systems, it is not surprising to find that in spontaneous or experimentally induced oligospermia or aspermia *(8, 9)* fructose levels are often above the normal average. Therefore, since the level of fructose in seminal plasma bears no relationship to sperm concentration, the "fructolysis index" often fails to accurately express the metabolic activity of sperm. For example, oligospermic bulls often deliver ejaculates high in initial fructose and out of proportion to the low sperm count. This may yield a high index and will over-evaluate the metabolic potency of the sperm. On the other hand, in samples with high sperm concentration and low initial fructose levels the sugar may become exhausted within an hour, thus yielding a low fructolysis index and an under-evaluation of sperm metabolism.

Another problem is posed by the quantity relationship of sperm to seminal fluid fructose. When calculated on an individual sperm basis, the turnover of fructose is progressively lowered with increase in sperm concentration *(2, 10, 19)*. It is evident from the foregoing that the problems arising during application of the "fructolysis index" are due to natural variation in concentration of sperm and initial fructose, degree of dilution, and type of buffer used, all of which may affect the metabolic behavior of sperm. Therefore, we have more critically examined the fructolysis reaction in order to determine whether an adjustment of these variables can be obtained.

EXPERIMENTAL PROCEDURE

The semen used for this study was collected by means of an artificial vagina from Holstein, Guernsey, and Shorthorn bulls at the Colorado A & M College Artificial Insemination Unit. The procedure for fructose analysis outlined below is a modification of the method of Roe *(17)* as adapted by Mann *(13, 14)*. When received in the laboratory, duplicate samples of 0.8 ml. of semen were diluted with 0.4 ml. of 0.125 *M* Na_2HPO_4 (pH adjusted to 7.4 with 0.1 *N* HCl). After gentle mixing, the sample vials were stoppered and incubated at 37° C. for 3 hours. Initially and at specified intervals (20, 40, 60, 80, 120, 180 minutes), 0.1 ml. of the semen-buffer mixture was removed from the incubation tubes and added to a 10 ml. tube containing 3.9 ml. of water. Two ml. of 2% $ZnSO_4$ were added. After mixing, 2 ml. of 0.4% NaOH were added; the contents of the tube were mixed and then heated in a near-boiling water bath and filtered hot.

Two ml. of the protein-free, clear filtrate were removed to a 10-ml. volumetric flask. After adding 2.0 ml. of 0.1% resorcinol in 95% ethanol, the flask contents

were diluted to volume with 30% HCl. A reagent blank was prepared similarly. The flasks were heated in a water bath at 80° C. for 15 minutes and then rapidly cooled in cold tap water.

The per cent transmission of light through the orange-red solution was determined on the Evelyn colorimeter with a wavelength of 520 mμ. The concentration of fructose was estimated from a standard curve. The sperm concentration was determined by hemacytometer. Statistical procedures for correlating fructolysis with nonreturns were according to Snedecor *(20)*.

RESULTS

The fructolysis index as proposed by Mann *(13)* is the milligrams of fructose utilized by 10^9 sperm in 1 hour at 37° C. As used by the authors *(6, 7, 8, 9)* it is the milligrams of fructose utilized by 10^9 sperm in any number of hours. In this way one can get a 1-, 2-, and 3-hour index which is accumulative rather than a 1-hour index for each individual hour. The accumulative index affords more flexibility in handling data.

A general formula for calculating the fructolysis index would be:

$$(1) \quad F.I. = \frac{(10^9)\ (\text{mg. fructose utilized per 100 ml. semen})}{a \times 10^5} = \frac{C_o - C_t}{a \times 10^{-4}}$$

where $F.I.$ is the fructolysis index, C_o is the initial concentration of fructose in milligrams per cent, C_t is the concentration of fructose in milligrams per cent at time t in hours, and a is the number of sperm per cubic millimeter of whole semen. The basic number of sperm involved in the fructolysis index is 10^9, and 10^5 puts a on a volume basis comparable to that of the numerator.

The formula is seen to be correct if the units are worked out as follows:

The units for $F.I.$ are mg/10^9 sperm; thus by substitution in equation 1

$$\text{mg}/10^9 \text{ sperm} = \frac{\text{mg}/100 \text{ ml.}}{\text{sperm}/\text{mm}^3 \times 10^{-4}}$$

This measurement of fructolysis is empirical, since the dimension of time as a variable is fixed to the limits of 1, 2, or 3 hours. In order to estimate the behavior of sperm over periods of time other than the hours specified, it is necessary to determine the order that best fits the reaction so that it may be possible to predict the fructose uptake by a sperm sample in any period of time wherein the sperm are viable.

If the removal of fructose by sperm is postulated to be independent of the concentration of fructose initially present, a zero order equation may be employed to express the rate of fructolysis as follows:

$$(2) \quad \frac{C_o - C_t}{t} = K$$

where C_o is the original concentration, C_t is the concentration at time t (in minutes) and K is the rate constant.

In any semen sample, fructose utilization should be directly proportional to the sperm concentration. In the above equation the value K, when derived from experimental results, should be adjusted for sperm count. The validity of this adjustment is, however, dependent on the degree of correlation between the sperm count and the actual amount of fructose utilized.

Correlation of fructose utilization to sperm concentration. To test the validity of adjusting the rate equation for sperm concentration, 230 semen samples were analyzed to determine the quantity of fructose used in 60 minutes, and the values obtained were plotted against the sperm count of the particular sample (Figure 1). It is evident that the degree of correlation was highly significant (0.88),

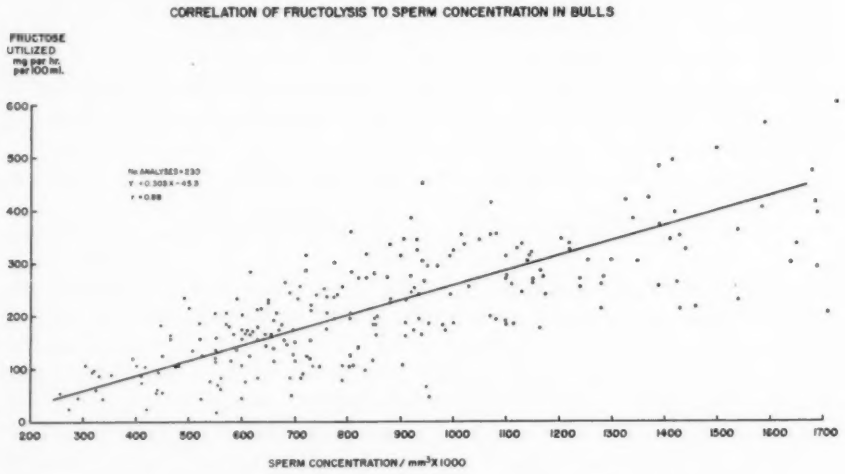

FIG. 1. Correlation of fructolysis to sperm concentration in bulls.

although a tendency of the function to deviate from a straight line was observed when the count rose to above 10^6 sperm per cubic millimeter. The observed deviation indicates that at high concentrations the utilization of fructose per spermatozoon declines, possibly because of the competition for substrate or a decrease of sperm surface exposed to substrate.

Removal of fructose from seminal plasma by sperm is almost directly proportional to the concentration of sperm (Figure 1). The concentration of sperm during any given analysis remains constant. Therefore, if the fructolysis reaction were zero order, the concentration of fructose plotted against time t should give a straight line. If the reaction does not fit zero order, this will not occur.

The rate of utilization of fructose considered as a first order reaction. Another series of 135 semen samples was analyzed for fructose content before incubation and at 20-minute intervals for 80 minutes and at the second and third hour of incubation. Figure 2 shows that when the concentration of fructose determined at each interval was plotted against time, a smooth decay curve

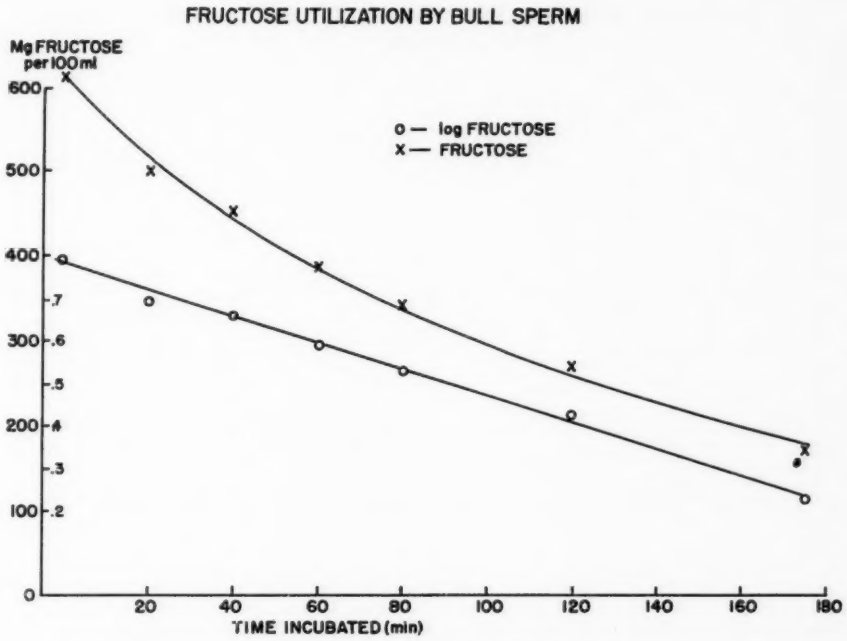

FIG. 2. Fructose utilization by bull sperm.

resulted, which is suggestive of a first order rather than a zero order reaction. Furthermore, when the log of the fructose concentration was plotted against time, a linear relationship was obtained. Since the utilization of fructose appears to be more suitably handled as a first, rather than a zero, order reaction, the rate of fructolysis may be determined by employing the first order equation, e.g.:

$$(3) \quad K = \frac{2.303}{\text{sperm count} \times t} \log \frac{C_o}{C_t}$$

where t is the time in minutes, C_o is the original concentration of fructose, and C_t is the concentration at time t.

Constancy of the fructolysis rate. If the fructolysis rate be measured it is desirable that it be steady over a known period of time. Since motility studies during the fructolysis test have shown a slight decline over 3 hours, it was expected that the rate would decline after prolonged incubation. The values shown in Figure 2 were recalculated by employing the first order equation shown above. The results, plotted as average rates ($K \times 10^9$), are shown in Figure 3. It will be seen that the rate was practically constant at all periods of measurement, although a slight, progressive decline in the rate was observed beyond 80 minutes, possibly due to decreased motility. It must be pointed out that the measurement of rate at periods earlier than 20 minutes proved to be impractical

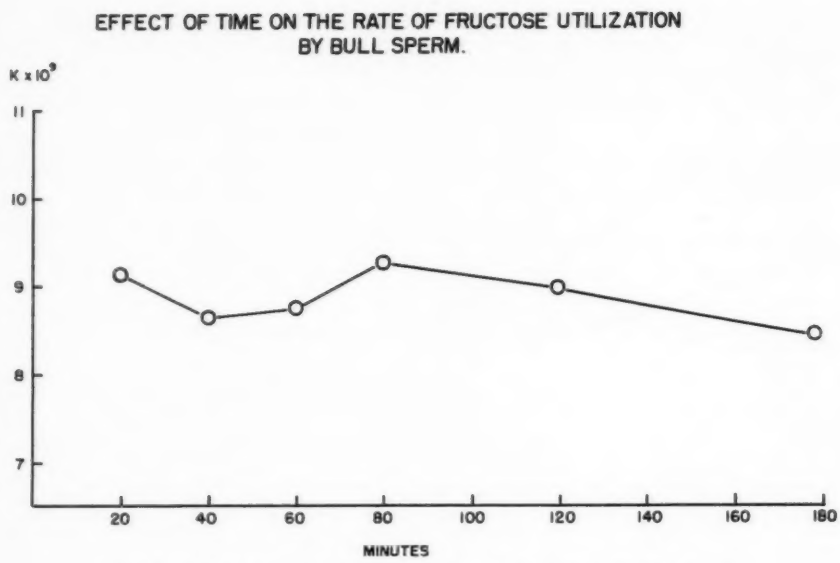

FIG. 3. Effect of time on the rate of fructose utilization by bull sperm.

because of time that had to be allowed for equilibration of the samples at the incubation temperature. For technical convenience, rate values determined subsequently were for samples that had been incubated for 60 minutes.

Variation of rate of fructolysis in individual semen samples. When the rate of fructose utilization in the 230 semen samples shown in Figure 1 was determined and the $K \times 10^9$ values obtained were arranged in a frequency distribution, it became apparent that the curve was skewed to the left (Figure 4). Since the mean value did not coincide with the highest frequency group, the curve was "normalized" by extracting the square root of K and multiplying it by 10^9, and the frequency distribution of these values was plotted similarly. It is apparent that the mean is now found in the group with the highest frequency. It is possible from this adjusted distribution curve to obtain comparisons about the mean between individual semen samples.

Discrepancies in the rate of fructose utilization by sperm. A true first order reaction is based on mass action kinetics where the decay or buildup of a substance is dependent only on the concentration of that substance with respect to the time of measurement. Since the decay of fructose from seminal plasma is dependent on many enzyme systems in sperm and the limiting reaction is not known, fructolysis cannot be considered a "true" first order reaction because many molecules are involved. Because the uptake of fructose by sperm is dependent on the number of cells present and because the inherent capacity of each cell to utilize the carbohydrate is limited, definite amounts of fructose will be removed from the seminal plasma.

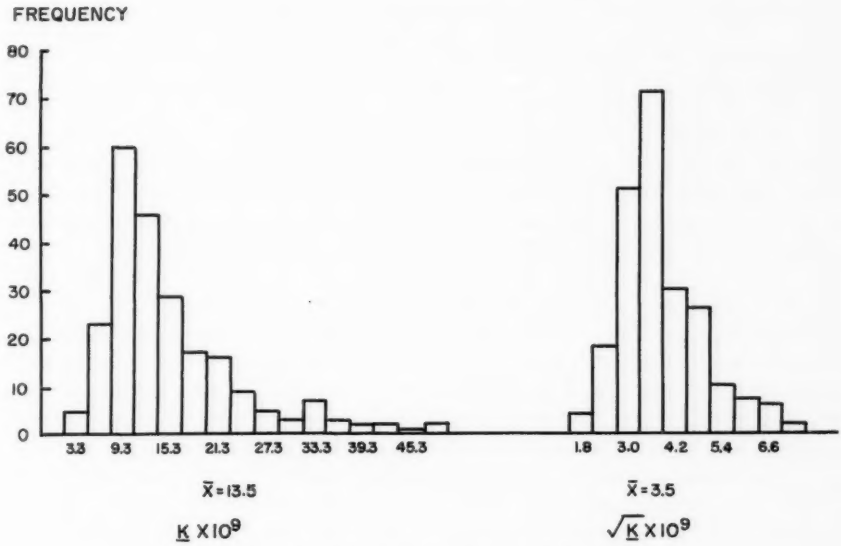

FIG. 4. Rate of fructose utilization by bull sperm.

When fructose is added to a sperm sample, the ability of the sperm to utilize the added amount is not affected but the initial fructose concentration is increased, resulting in an apparent lowering of the determined K value. To illustrate, in Equation 3 if C_o is increased, C_t will also increase, since the removal of fructose is sperm-limited. The resulting fraction, C_o/C_t, in the log value is decreased by such manipulation and the derived K is lowered.

To eliminate this difficulty, arising when fructose is added to semen, values used subsequently were adjusted by holding C_o to 500 mg. %, and the amount of fructose necessary to accomplish this was subtracted or added in the denominator (C_t). This adjustment held the initial concentration to the more physiological level at which the sperm remove fructose but caused no alteration of the fraction C_o/C_t.

Use of the adjusted fructolysis rate determination for prediction of bull fertility. The square root of the adjusted rate of fructolysis, discussed in the preceding section, ($\sqrt{K} \times 10^9$) was determined individually for nine bulls on a between-bulls basis over a 9-month period. The breeding coefficient between bulls was calculated from 3,277 services on a 60-90 day nonreturn basis, and the degree of correlation between the rate and the breeding coefficient was computed *(20)*. It was found that the coefficient of correlation was 0.604 with an associated error of 0.084, which is clearly significant. The fructolysis index for the same semen samples, reported earlier *(9)*, was also highly correlated ($r = 0.770 \pm 0.153$). Although the degree of correlation is not as high for the rate data, the associated error is considerably diminished.

DISCUSSION

The use of the fructolysis index in predicting the breeding potential of dairy bulls has proved itself for 3 years at this Station, although its value for predicting fertility for samples within bulls could not be determined from these data because of insufficient artificial services for individual semen samples. The determination of the index is relatively easy, and since it has consequently shown a high correlation with breeding performance between bulls, it can be considered a useful measure of fertility. From the results obtained by employing the first order equation for the measurement of fructose metabolism by sperm it will be seen that its correlation with nonreturns is also high and comparable with the fructolysis index in this respect. It must be acknowledged that the rate determination has more basis in fact than does the fructolysis index, since this value is better founded on the principles of mass action kinetics. The more empirical fructolysis index and the rate determination are both correlated with breeding performance; however, the former has proven of definite use in fertility prediction because of its reproducibility and the relative ease by which it is obtained. For research in sperm metabolism the first order rate calculation should be employed because it more truly represents the manner of fructose utilization by sperm and is independent of measurement within fixed periods of time.

SUMMARY

Fructose conversion by 135 semen samples from bulls of acceptable fertility was determined at 20-minute intervals for 80 minutes and hourly thereafter during 3 hours incubation at 37° C. at a 2:1 dilution with 0.125 *M* phosphate buffer (pH 7.4). The removal of fructose by sperm fitted a first order, rather than a zero order, reaction under the conditions of the analysis. By using this principle for determining fructose-sperm reaction rates, a highly significant correlation with nonreturns of 0.604 ± 0.084 was observed, which compares favorably with the fructolysis index as a means of estimating probable fertility of bulls. Although the fructolysis index is a satisfactory tool for prediction of fertility, the rate determination, adjusted for sperm concentration, is a more justifiable measurement of the metabolic behavior of individual semen samples because it is shown to more truly represent the manner by which sperm remove fructose from seminal plasma.

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EFFECT OF PROTEINS OF PLANT AND ANIMAL ORIGIN ON THE GROWTH, REPRODUCTIVE DEVELOPMENT AND SEMEN PRODUCTION OF YOUNG DAIRY BULLS[1,2]

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Numerous studies have been made of the effect of quality of protein in the ration upon the semen production of mature bulls, and those studies reported before 1949 have been reviewed by Branton *et al. (1)*. Recent as well as earlier investigations of this problem have yielded conflicting results *(11, 13)*.

Effects of protein quality on the growth and development of young dairy sires have not been investigated extensively, although Jones *et al. (5)* have reported that a ration adequate for growth is adequate for semen production. In view of the possible effects of nutrition upon reproductive development and performance, an investigation of the effect of protein quality upon growth, reproductive development, and quality of semen produced by the young bull was undertaken, and the results are reported herein.

EXPERIMENTAL PROCEDURE

Three experimental groups were used in studying the effects of the source of dietary protein upon the growth, sexual development, and early semen quality of bulls. As indicated in Table 1, unpasteurized skimmilk provided most of the protein for one group (FAP), animal feeding grade dried skimmilk was used for the second group (HAP), and the third group received a ration containing vegetable proteins only (VP).

Calves were started on the experiment at an average age of 3 weeks. The calves were grade Holstein twins obtained from farms in Pennsylvania and were heterozygotic according to blood typing, although they had shown some promise of being monozygotic when examined for phenotypic characters. They were assigned to experimental groups as twins so that both members of a set were not in the same group. After assignment to treatments, they were handled as individual, unrelated animals. Nine sets of twins were used; thus six calves were assigned to each group.

Whole milk was gradually reduced and discontinued when the calves were 6 weeks of age. Hay was fed at the rate of 1 lb. per 100 lb. of body weight per day; second cutting alfalfa or clover was fed until the animals were 52 weeks of age, and a timothy-clover mixture was fed thereafter. The concentrate mixture was fed at a rate calculated to maintain total digestible nutrient intake at the

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TABLE 1
Ingredients of the concentrate mixtures

	FAP	HAP	VP
	(lb.)	*(lb.)*	*(lb.)*
Fluid skimmilk	246[a]	—	—
Nonfat dry milk solids	—	26	—
Ground yellow corn	20	20	36
Crushed oats	25	25	21
Wheat bran	19	19	10
Soy bean oil meal	—	—	22
Linseed oil meal	8	8	9
Mineral mix[b]	1.2	1.2	1.2
Salt	0.8	0.8	0.8
Total	100.0	100.0	100.0
TDN	75.3	75.3	75.3
Digestible protein	17.4	17.4	17.4

[a] Not mixed with ration but fed concurrently. Considered on air dry basis (26 lb.) for calculating weight of the ration.
[b] Commercial mixture analyzing 27.0% calcium, 0.6% magnesium, 0.025% copper, 0.1% iron, 5.0% phosphorus, 0.6% manganese, 0.0125% iodine, and 0.01% cobalt.

recommended level *(8)*. Consumption of skimmilk ranged from 8 lb. daily at the start of the experiment to 18 lb. daily at the end of the trial.

Approaching sexual maturity was detected by using a heifer of appropriate size as a teaser, starting at 24 weeks of age *(3)*. Sexual maturity was recorded as the age at which the first ejaculate containing motile spermatozoa was obtained. A single semen sample was collected from each bull biweekly through the 60th week, weekly from 61 to 70 weeks, and semiweekly thereafter. Semen quality and quantity tests were performed on each ejaculate and included volume of ejaculate, number of spermatozoa per milliliter, per cent of spermatozoa initially motile, per cent of unstained (live) spermatozoa, and the per cent of motile spermatozoa after 5, 10, and 15 days of storage at 5° C. Procedures for these tests have been reported previously *(3)*.

Blood samples were obtained at 12-week intervals from 12 to 72 weeks of age and were analyzed for hemoglobin, total serum protein, urea, and nonprotein nitrogen by the methods of Sanford and Sheard *(12)* modified, Looney and Walsh *(7)*, Northup *et al. (10)*, and Koch and McMeekin as described by Hawk *et al. (4)*, respectively.

RESULTS AND DISCUSSION

Growth was measured by changes in body weight, height at withers, and heart girth. Data on initial measurements and changes during the experimental period are presented in Table 2. Calves receiving liquid skimmilk gained weight more rapidly than calves on the other treatments during the first few weeks of the experiment and tended to be slightly heavier throughout the trial, although the differences were not significant. Effects on height at withers and heart girth were less apparent than the effects on body weight. Consumption of total digestible nutrients and digestible protein, based upon actual chemical analyses and the average digestion coefficients of Morrison *(9)*, was similar for the three groups.

TABLE 2

Average initial body measurements, changes in body measurements, and total digestible nutrient and digestible protein consumption

Protein source	Initial measurement	Change during the age period in weeks				
		1-20	21-40	41-60	61-80	1-80
			Body weight *(lb.)*			
FAP	97	186	283	312	265	1,047 ± 14[a]
HAP	95	171	291	314	241	1,017 ± 23
VP	99	174	298	315	221	1,007 ± 19
			Height at withers *(cm.)*			
FAP	75.0	21.5	18.5	11.8	8.4	60.3 ± 0.84
HAP	74.2	19.6	19.1	13.2	7.9	59.8 ± 1.26
VP	74.8	20.9	19.7	11.8	8.3	60.7 ± 1.05
			Heart girth *(in.)*			
FAP	33.1	13.6	11.6	9.5	5.8	40.5 ± 0.68
HAP	32.4	12.4	12.2	9.9	6.5	40.9 ± 0.76
VP	33.1	12.8	13.7	9.9	4.8	41.3 ± 0.57
			TDN consumed *(lb.)*			
FAP		441	931	1,319	1,546	4,193 ± 39
HAP		427	905	1,303	1,540	4,134 ± 54
VP		437	920	1,312	1,544	4,164 ± 61
			Digestible protein consumed *(lb.)*			
FAP		97	199	265	259	815 ± 12
HAP		92	193	264	276	816 ± 19
VP		93	192	264	276	823 ± 14

[a] Standard error of the mean.

TABLE 3

Average concentrations of blood constituents

Protein source	Age of bulls in weeks					
	12	24	36	48	60	72
			Hemoglobin *(g. %)*			
FAP	11.2 ± 0.64[a]	11.1 ± 0.46	11.1 ± 0.27	11.7 ± 0.42	12.0 ± 0.47	12.0 ± 0.63
HAP	11.5 ± 0.57	11.2 ± 0.15	11.2 ± 0.66	11.3 ± 0.77	11.1 ± 0.65	12.4 ± 0.48
VP	12.0 ± 0.68	11.4 ± 0.59	11.0 ± 0.51	11.3 ± 0.78	10.9 ± 0.48	12.4 ± 0.41
			Total serum proteins *(g. %)*			
FAP	6.8 ± 0.53	6.9 ± 0.38	7.1 ± 0.34	7.9 ± 0.25	8.2 ± 0.14	8.2 ± 0.21
HAP	7.1 ± 0.43	6.9 ± 0.30	8.8 ± 1.47	7.9 ± 0.21	8.2 ± 0.13	7.9 ± 0.46
VP	7.8 ± 0.77	7.6 ± 0.55	7.7 ± 0.18	8.1 ± 0.38	8.0 ± 0.17	8.1 ± 0.21
			Nonprotein nitrogen *(mg. %)*			
FAP	26 ± 2.5	25 ± 3.4	25 ± 3.5	31 ± 1.2	25 ± 1.5	30 ± 2.1
HAP	31 ± 1.7	28 ± 3.6	32 ± 2.0	29 ± 2.7	27 ± 1.6	33 ± 1.5
VP	30 ± 3.2	34 ± 2.6	28 ± 4.0	33 ± 1.0	28 ± 1.6	32 ± 2.1
			Urea *(mg. %)*			
FAP	33 ± 1.3	25 ± 4.1	30 ± 4.1	35 ± 1.6	29 ± 2.4	32 ± 3.5
HAP	39 ± 4.3	33 ± 3.5	32 ± 5.3	37 ± 2.6	35 ± 1.9	38 ± 2.6
VP	45 ± 4.6	36 ± 6.1	38 ± 3.1	42 ± 1.7	36 ± 1.8	38 ± 3.8

[a] Standard error of the mean.

Average values obtained from blood analyses are presented in Table 3. None of the differences attain statistical significance as determined by analysis of variance *(15)*, but there was a consistent tendency for the concentrations of both urea and nonprotein nitrogen to be lower for FAP than for either HAP or VP. When urea nitrogen was deducted from total nonprotein nitrogen, it was found that urea nitrogen probably accounted for all of the difference observed in total nonprotein nitrogen.

Sexual maturity, as measured by the age at which the first ejaculate containing motile spermatozoa was obtained, was reached at an average age of 47 (range 34-58), 45 (39-52), and 48 (40-54) weeks for the FAP, HAP, and VP groups, respectively. The average body weight of the bulls at the time the first ejaculate was collected was 697 (range 494-880), 630 (508-739), and 689 (555-813) lb. for FAP, HAP, and VP, respectively. Neither the differences in ages nor those in weights approached significance when tested by analysis of variance *(15)*.

Average values for the various semen characteristics are shown in Table 4. The data through 80 weeks of age include results with all 18 animals; because

TABLE 4

Summary of semen characteristics

Protein source	Age of bulls in weeks			
	to 60[a]	61-70[b]	71-80[c]	81-90[c,d]
	Volume of ejaculate *(ml.)*			
FAP	2.8	3.6	3.4	3.8
HAP[e]	2.4	3.0	2.6	2.5
VP	3.1	3.6	3.4	3.8
	Number of spermatozoa $\times 10^6$ per ml.			
FAP[f]	624	904	1,070	1,281
HAP	364	752	899	1,030
VP	453	702	888	1,009
	Initial motility *(%)*			
FAP	54	57	57	59
HAP	43	50	51	55
VP	47	50	51	48
	Total motile spermatozoa $\times 10^6$ per ejaculate			
FAP[e]	1,101	1,873	2,135	2,893
HAP	392	1,170	1,274	1,403
VP	644	1,307	1,543	1,851
	Unstained (live) spermatozoa *(%)*			
FAP	62	68	67	74
HAP	50	57	63	68
VP	56	60	60	62
	Motility after 5 days storage at 5° C. *(%)*			
FAP	39	36	37	36
HAP	32	38	39	38
VP	34	35	38	35

[a] One ejaculate collected biweekly.
[b] One ejaculate collected weekly.
[c] One ejaculate collected semiweekly.
[d] Four bulls per group.
[e] Significant at 1% level of probability.
[f] Significant at 5% level of probability.

of space limitations only the first four replications in each group were continued on the trial to 90 weeks of age. The volume of ejaculate was smaller ($P = < 0.01$) for HAP than for the other groups, whereas the concentration of spermatozoa per milliliter of semen was higher ($P = < 0.05$) for FAP than for the other groups. Bulls receiving FAP produced more total motile spermatozoa per ejaculate than did those on HAP or VP. Significant differences between treatments were not observed in the other semen characteristics determined. The per cent motile spermatozoa after 10 and 15 days of storage also was determined; the trends for these observations were similar to those shown for motility after 5 days of storage.

These results indicate that proteins of vegetable origin probably are equal to those of animal origin insofar as any effect upon the attainment of sexual maturity is concerned. On the other hand, an apparent advantage is shown in favor of animal protein in the number of motile spermatozoa produced. With mature bulls, improvement in semen quality was obtained by some investigators *(6, 14)* by feeding animal proteins, but others have reported that animal proteins have no advantage over plant proteins *(1, 2, 11)*. It is possible that some of the disagreement may be due to the quality of the control ration; an animal protein ration may possess some advantage over poor quality low-protein plant rations but little or no advantage over vegetable proteins of better quality and/or quantity.

Results may be dependent to some extent upon the rigor of the testing procedure; differences might not show up when single ejaculates are collected at weekly intervals, whereas they might appear if the bulls were collected more frequently. The practice of collecting semen from young bulls frequently (once weekly starting at 61 weeks and twice weekly after 70 weeks of age) was employed in this trial to elucidate differences if they existed; such differences might not have appeared had a more conservative testing procedure been employed.

Although the feeding of fluid skimmilk to growing bull calves resulted in an increased production of motile spermatozoa, the use of skimmilk may not be practical in many areas because of the cost involved. Whether the advantage gained by feeding fluid skimmilk has any prolonged effect may be questionable; it was not possible to study any such effects in the present investigation.

SUMMARY

Eighteen Holstein bull calves (six per treatment) were used to determine the effect of dietary protein quality upon the growth, reproductive development, and the quality of semen produced by young bulls. The treatments included animal protein as fluid skimmilk, animal protein as animal feeding grade dried skimmilk, and vegetable protein.

Source of protein had no significant effect upon growth, the concentration of hemoglobin, total serum protein, urea, and nonprotein nitrogen in the blood, or the age or size at which viable spermatozoa were first collected from the bulls.

Tests of semen quality indicated that volume of ejaculate was adversely affected by the dried skimmilk ration, and number of spermatozoa per milliliter of semen was increased by the liquid skimmilk ration; initial motility, rate of motility, per cent live (unstained) spermatozoa, and survival upon storage at 5° C. were not affected by the treatments used.

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FURTHER STUDIES ON THE INFLUENCE OF DIETARY CALCIUM AND PHOSPHORUS ON THE INCIDENCE OF MILK FEVER

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Previous studies have indicated that low-calcium high-phosphorus prepartal diets will lower the incidence of milk fever (parturient paresis) in dairy cattle. It was suggested that such diets exert their effect by causing parathyroid stimulation, thus providing sufficient calcium mobilizing hormone to avert the drop of blood calcium resulting from the initiation of lactation *(1)*.

Since the diets used in this study were somewhat unpalatable and did not furnish sufficient nutrients for desired weight gains before parturition, attempts have been made to find rations which will correct these deficiencies and still prevent milk fever. This paper presents the data obtained from milk fever susceptible cows fed such prepartal rations under field trial conditions.

EXPERIMENTAL PROCEDURE

The animals used in this study were from three high producing herds of Jersey cattle. Approximately one month before the expected calving date, cows that were believed susceptible to milk fever and had calved at least twice previously were held in dry lots and fed the experimental rations individually in stanchions. In view of the low roughage to concentrate ratio, the daily ration was divided, one half being fed in the morning, the other half in the evening. After parturition, the cows received the type of ration usually fed for milk production.

Lactation records under the program of the Dairy Herd Improvement Association were available from one of the herds supplying the majority of the data reported in this paper. Blood samples were collected by venous puncture from most of the experimental animals of this herd on the day of parturition and 4 days following and were analyzed for total serum calcium by the method of Clark and Collip *(2)*.

The basic prepartal diet fed to all three groups of cows consisted of oat hay and a high phosphorus concentrate mixture. The latter was composed of 40% ground barley, 30% rolled barley, 25% wheat bran, 5% cottonseed meal, and monosodium phosphate (Technical grade). The amount of hay fed and the quantity of phosphate added to the concentrate mixture were altered in order to vary the dietary calcium and phosphorus intake. The rations fed in the three trials were as follows: Group 1 (26 cows) received a daily ration of 8 lb. of oat hay and 8 lb. of the basic concentrate mixture supplemented with 1.5% monosodium phosphate. The daily calcium and phosphorus intakes, as estimated from the average composition of feeds presented by Morrison *(9)*, were approximately 11 and 44 g., respectively. This ration supplied 102% of the minimum require-

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ment of digestible protein and 78% of the total digestible nutrients for a 1,000-lb. cow during the last 2 to 3 months of pregnancy, as recommended by the Morrison standards. Group 2 (19 animals) received the same ration except that the supplemental phosphate was increased to 5%, resulting in a daily intake of 11 g. of calcium and 74 g. of phosphorus. Group 3 (28 cows) received 5-6 lb. of oat hay and 10-12 lb. of the concentrate mixture supplemented with 5% monosodium phosphate. The absolute levels of hay and concentrate fed varied with the size of the animal, larger cows receiving 6 lb. of hay and 12 lb. of the concentrate, smaller ones 5 and 10 lb., respectively. The daily calcium intake was approximately 8.5-10 g., phosphorus intake was estimated to be 88-102 g. The ration furnished 104-125% of the minimum requirements of digestible protein and 77-95% of the TDN requirement.

The influence of the low-calcium prepartal diets upon the incidence of milk fever was assessed by comparing the number of cows with previous histories of

TABLE 1

Incidence of milk fever, lactation records and levels of serum calcium for cows of Group 1 (Daily ration, 8 lb. oat hay and 8 lb. concentrate supplemented with 1.5% monosodium phosphate)

Cow No.	Age	Previous history of milk fever	Milk fever	Difference in production at 90 days of lactation		Serum calcium	
				Butterfat	Milk	1st day postpartum	4th day postpartum
	(years)			*(lb.)*	*(lb.)*	*(mg/100 ml.)*	
362	12	−	−	8	20	9.36	9.81
409	11	−	−	33	450		11.04
413	11	−	−	−59[c]	−1,450[c]	8.33	12.05
429	11	+[a]	−	60	850	9.73	9.90
512	10	−	−	2	−550	10.38	9.90
519	10	+	−			7.30	9.54
607	10	+	+[b]	38	400	7.47	
660	9	+	−	30	580	9.54	10.30
717	8	−	−	35	630	8.36	9.81
725	8	−	+	−40	−1,250	4.34	
744	8	−	−	16	−400		
751	8	+	−	−94	−1,340		
757	8	−	−	11	−230	9.54	11.55
839	7	−	−	−26	−1,330	9.78	10.38
850	6	−	−	19	350	6.23	10.10
870	6	−	−			7.14	
873	6	−	−	−24	−210	7.85	9.98
876	6	−	−	45	820	7.35	10.50
889	6	−	−	−12	−100		
893	6	−	−	−64	−1,350		
916	5	−	−	19	350	10.00	9.63
919	5	−	−	30	890	11.32	
926	5	−	−	24	250	9.30	9.68
955	5	−	−	78	720	9.30	9.90
975	4	−	−	51	550	7.74	10.23
7,700	7	−	−	6	−50	7.30	11.82
			Mean difference	+8	−58		

[a] Previous history of milk fever.

[b] Clinical symptoms of milk fever.

[c] Decrease in production after feeding the low calcium prepartal diet as compared to the preceding lactation.

this condition with the occurrence of milk fever following the use of such prepartal rations.

RESULTS AND DISCUSSION

The results obtained for the three groups of cows are presented in Tables 1 through 4. Of the 26 cows of Group 1, five with previous histories of milk fever, two exhibited symptoms of milk fever. Two of the 19 animals of Group 2 (10 with previous histories) and only one of the 28 cows of Group 3 (12 with previous histories) developed milk fever, although a number of the experimental cows were hypocalcemic shortly after parturition without displaying outward symptoms of milk fever. This was particularly true of Group 1 (Cows 850, 870, 519, 7,700, and 876) although a few cows of Group 2 (Cows 598 and 650) and of Group 3 (Cows 877, 759, and 607) also had low serum calcium levels after parturition. It would appear that under these conditions hypocalcemia does not result in the usual manifestations of milk fever unless the serum calcium level falls below 6 mg. %. Cow 607 (Group 1) is an exception to this statement, since the total serum calcium level was 7.74 mg. % 10 hours after parturition. In this cow, the milk fever symptoms were not severe, the cow did not "go down," and intravenous calcium administration was immediately effective. The symp-

TABLE 2

Incidence of milk fever, lactation records and levels of serum calcium for cows of Group 2 (Daily ration, 8 lb. oat hay and 8 lb. concentrate supplemented with 5% monosodium phosphate)

Cow No.	Age	Previous history of milk fever	Milk fever	Difference in production at 90 days of lactation		Serum calcium	
				Butterfat	Milk	1st day postpartum	4th day postpartum
	(years)			*(lb.)*	*(lb.)*	*(mg/100 ml.)*	
25	12	−	−	93	1,570		
55	12	−	−	49	850	9.21	9.60
100	7	+[a]	−				
101	9	+	−				
102	10	+	−				
103		+	−				
104	9	+	−				
358	12	+	−	17	270		
359	12	+	−			9.70	
407	11	+	−	−41[c]	−940[c]	8.25	9.82
598	10	+	−	−36	−790	6.15	
604	10	+	+[b]			5.65	
643	9	−	−	49	−320		
650	9	−	−	44	650	6.66	7.94
696	8	−	−	−4	−250	8.79	9.05
756	8	−	−	80	1,250	9.56	11.02
880	7	−	−	1	−750	9.37	
895	6	−	+	1	−300	5.59	
922	6	−	−	−31	−850	9.70	
			Mean difference	+18	+32		

[a] Previous history of milk fever.
[b] Clinical symptoms of milk fever.
[c] Decrease in production after feeding the low-calcium prepartal diet as compared with the preceding lactation.

TABLE 3

Incidence of milk fever, lactation records and levels of serum calcium for cows of Group 3 (Dairy ration, 5-6 lb. of oat hay and 10-12 lb. concentrate supplemented with 5% monosodium phosphate)

Cow No.	Age	Previous history of milk fever	Milk fever	Difference in production at 90 days of lactation		Serum calcium	
				Butterfat	Milk	1st day postpartum	4th day postpartum
	(years)			*(lb.)*	*(lb.)*	*(mg/100 ml.)*	
C87		+[a]	−				
148	6	−	−	−45[c]	−720	12.28	13.30
382	12	+	−			9.40	9.45
397	12	+	−	2	850	8.55	10.63
407	12	+	−	96	900		
598	11	+	−	15	870		
607	11	+	−			7.30	9.60
650	10	−	−	49	580	8.07	9.73
688	10	−	−	59	1,140	9.54	9.20
704	10	−	−	−24	−450	9.68	9.83
726	9	+	−	24	550		
744	9	−	−	54	1,420	8.90	
757	9	−	−	32	720	9.50	11.71
759	9	+	−	59	100	6.61	9.26
783	8	−	−	20	330	8.80	10.61
783	9	−	−			9.48	11.78
788	8	−	−	−14	−80	10.30	11.10
833	7	+	−	−50	−1,030	10.40	
876	7	+	−	6	280		
877	7	−	−	19	300	6.85	9.70
880	7	−	+[b]	67	1,600	5.60	
893	7	−	−	18	−110	8.70	9.84
895	7	+	−			9.00	10.56
918	6	−	−	19	−320	9.00	
B924		+	−				
955	6	−	−	−54	−700	8.70	
1,066	4	−	−			8.19	8.15
1,072	4	−	−			8.51	
			Mean difference	+18	+311		

[a] Previous history of milk fever.
[b] Clinical symptoms of milk fever.
[c] Decrease in production after feeding the low-calcium prepartal diet as compared with the preceding lactation.

toms were more serious in the four other animals, but they also quickly recovered upon receiving 500 ml. of a 23% solution of calcium borogluconate.

The data indicate that the prepartal rations fed to Groups 2 and 3, resulting in daily calcium and phosphorus intakes of approximately 8.5-11 g. and 74-102 g., respectively, have lowered the incidence of milk fever. Even though the number of cows in Group 1 with previous histories of this condition is small, it also appears that the prepartal diet fed to these animals, which has provided a daily intake of 11 g. of calcium and only 44 g. of phosphorus, has resulted in at least some reduction in the incidence of milk fever. A number of the animals of this group were young cows that had calved only two or three times previously. Since milk fever is not common in such animals *(8)*, there was little opportunity for many of them to have had prior attacks. An attack of milk fever at one parturition does not necessarily imply that this condition will occur at subse-

TABLE 4
Summary of results

Group No.	No. of cows	Approximate[a] daily intake of Ca and P		No. of cows with previous history of milk fever	Incidence of milk fever
		Ca	P		
		(g.)	*(g.)*		
1	26	11	44	5	2
2	19	11	74	10	2
3	28	8.5-10	88-102	12	1

[a] Estimated from the average composition of feeds (Morrison, F. B., *Feeds and Feeding*, 21st ed., Table 1. 1951).

quent parturitions, but this is often true *(8)*. In fact, several of the cows have developed milk fever for the past several years. This is particularly true among the animals of Group 3.

Although all three prepartal rations resulted in adequate weight gains before parturition, the question arises as to whether the low-calcium prepartal diets are detrimental to the subsequent level of milk production. Forbes *et al. (4)* have shown that moderate to high producing dairy cattle are in negative calcium balance during the first part of the lactation period but store sufficient amounts of calcium during the latter part of lactation and during the dry period to renew body stores. Usual management procedures allow a dry period of at least 2 months. Since the low-calcium diets are fed for only 1 month before parturition, sufficient calcium storage should occur before this time, particularly if the production ration and the ration fed during the first part of the dry period contain ample calcium. Under these conditions there is little danger of a serious depletion of the skeletal calcium reserves. Low calcium diets, more rigorous than those employed in these trials, have had little influence upon reproduction or lactation in dairy cattle *(3)*.

The differences in butterfat and total milk production between the lactations immediately preceding and those following the use of the low-calcium prepartal diets are presented in Tables 1 through 3. The 90th day of lactation was chosen for this comparison, since it was believed that any influence the rations might have would be manifest in the early stages of lactation. Although production by the animals of Group 3 (Table 3) appeared to increase after the employment of the low-calcium ration, none of the differences in any of the groups was statistically significant.

The question also arises as to the possibility of the prepartal rations resulting in vitamin A deficiency. The Committee on Animal Nutrition of the National Research Council recommends a daily intake of 90 γ of carotene per pound of body weight during the last 2 to 3 months of gestation *(7)*. Kuhlman and Gallup *(6)*, however, observed no detrimental effects when the daily ration fed to Jersey cattle during the last 2 to 3 months of the gestation period contained as little as 40-45 γ of carotene per pound of body weight. Assuming that the carotene content of the oat hay used in the above low-calcium diets contained 8 mg. per pound *(7)*, Groups 1 and 2 received approximately 64 γ of carotene per

pound of body weight per day, an amount well above these minimum requirements, and Group 3 received about 40 γ of carotene per pound of body weight per day. The fact that vitamin A can be stored in the liver during periods of liberal dietary intake in amounts sufficient to require several months of depletion before symptoms of deficiency occur *(5)* makes it unlikely that the prepartal rations will cause reproductive difficulties associated with inadequate levels of vitamin A. Parturition appeared to be normal in all of the animals fed the low-calcium prepartal diets, and, with the exception of those developing milk fever, neither the cows nor the calves appeared to suffer from a lack of vitamin A. However, the findings of Spielman *et al. (10)*, who have demonstrated that vitamin A supplementation of a presumably adequate prepartal ration will result in increased weight gains and a lowered incidence of scours in newborn calves, indicate that the addition of vitamin A to the low calcium ration might be beneficial.

SUMMARY

High-producing Jersey cattle, many with previous histories of milk fever, have been fed low-calcium, high-phosphorus prepartal diets consisting of oat hay and a basal concentrate mixture composed of 40% ground barley, 30% rolled barley, 25% wheat bran, 5% cottonseed meal, and monosodium phosphate (Technical grade). The incidence of milk fever has been ascertained. Postpartal serum calcium levels have been determined and lactation records obtained from most of the animals.

Two of 26 cows, five with previous histories of milk fever, fed a daily ration of 8 lb. of oat hay and 8 lb. of the concentrate mixture supplemented with 1.5% monosodium phosphate, exhibited symptoms of milk fever. Two of 19 cows (10 with previous histories of milk fever), fed the same ration except for the addition of 5% phosphate, and only one of 27 cows (12 with previous histories of milk fever), fed a daily ration of 5-6 lb. of oat hay and 10-12 lb. of the 5% phosphate supplemented concentrate mixture, developed milk fever.

All three prepartal rations allowed adequate weight gains before parturition and had no adverse effects upon parturition, the subsequent lactation records, or the health of the calves.

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THE EFFECT OF NURSING CALVES ON MILK PRODUCTION OF IDENTICAL TWIN HEIFERS

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It is generally accepted that the simplest method of producing choice veal is to allow calves to nurse cows producing enough milk to satisfy their appetites. On many farms, especially in periods of low prices for condensery, cheese, or powder milk or butterfat sold for buttermaking, the practice of producing veal in this manner is widely followed. As a result, little milk is sold from many cows until after their calves are vealed, and the calves take all of the production of some cows until they are vealed. The effect of this practice upon the subsequent production of the cows has been questioned, but a feasible method of determining the effect with ordinary cows has not been devised. Experience with identical twin heifers at the University of Tennessee and other stations has shown that members of such pairs can be expected to produce nearly the same amount of milk of the same composition if they are treated alike *(1, 3, 4, 5, 8)*. Therefore, identical twin heifers were used in this experiment to compare the production of nursed heifers with their nonsuckled mates. Limited information regarding the veal-feeding method upon the economy and quality of veal production was also obtained.

EXPERIMENTAL PROCEDURE

Four sets of identical twins for this experiment were purchased from dairy farmers and moved to the University of Tennessee farm at ages of 6, 11, 14, and 17 months. Monozygosity of each pair of twins was determined by uniformity in size and all features of body conformation; by identical hair color distribution on the body, with the exception of spotting; by similarity of actions and temperament; and by blood antigen typing, which showed no within pair differences or suspected admixtures. Two sets were grade Jerseys, one was grade Guernsey, and one was a Jersey × Guernsey cross. They were maintained together under normal uniform herd management for heifers and were fed solely roughage ad lib. after 12 months of age. They were bred to calve at or shortly after 2 years of age, at which time all heifers were normal in size and condition for their age and breed. One set had been bred to a Hereford bull just before being purchased, another was bred to a Jersey bull, and two were bred to Holstein-Friesian bulls. In the second lactation the former two pairs were also bred to Holstein-Friesian bulls. Cross breeding to Holsteins was practiced because it was expected to give a better veal than either Jersey or beef breed crosses.

The twins within pairs calved an average of 15 days apart, with a range of 4 to 24 days. As the heifers freshened they were assigned to either the milking

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or nursing treatment according to the size and sex of their calves, an attempt being made to keep the two calf groups comparable. Calves were separated from the milked heifers at 1 day of age, and thereafter all milk was removed by machine milking (followed by limited hand stripping). The calves were fed their dams' milk by nipple pail at a liberal rate, but not ad lib. The fed calves were given increasing allowances of milk three times daily for 10 days, by which time they were getting 18 to 20 lb. per day. Then they were fed twice daily as much as they desired up to 20 lb. per day. This maximum was arbitrarily established for two reasons: *(a)* Some of the heifers were not expected to maintain that level of production for the time required to feed the veal, and *(b)* there was some apprehension concerning digestive disturbances that might follow strictly ad lib. twice-daily feeding. Access to hay and calf starter also was allowed. The nursing calves were left with their dams and allowed to nurse almost at will during the first 10 days. After that the dams were turned with their calves for at least 1 hour twice a day for nursing. Three of the first lactation twins were not milked after nursing because the calves seemed to be taking nearly all of their milk after the first week. The fourth first-lactation twin and two in their second lactation after nursing were milked with their mates in the milking parlor from the first day of lactation. All mates were fed and handled alike, with the exception of nursing, throughout the experiment. After the veals were sold, all twin-pairs were milked together by the same milker.

All milk weights were recorded. Daily composite milk samples were tested for butterfat and total solids once each week. The calves were weighed at 7-day intervals. When they had reached normal veal size, 180 to 200 lb., they were sold by grade at a local packing plant. The carcass was graded by an official grader. Weights of the wet and cooled carcasses were obtained for calculating dressing percentages of the veals.

RESULTS

The experiment was carried out according to plan without serious complicating incidents through the first lactation of all four sets of twins. At the second calving, one heifer calved 4 weeks early with a dead calf, which eliminated that pair, and another pair was shifted to another experiment. The two remaining pairs were compared in their second lactations. All twins milked very nearly alike within pairs during the last parts of their lactations. Since one pair milked for only 180 days, the six-pair average comparisons have been calculated to 160 days of the lactation. The total daily milk yield of the six twins in each group is plotted in Figure 1 according to the actual days in lactation. The six pairs of calves were sold at the four different times indicated by the letters, A-D. It is clearly evident that the nursed twins did not milk as well as their mates until several weeks after vealing the calves.

The daily production of the six pairs of twins is plotted in Figure 2 according to the days after vealing the calves. This comparison shows that the average time after vealing necessary for the twins to attain equal production was about 6

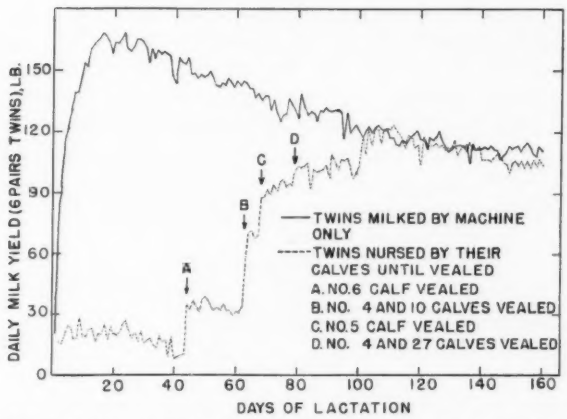

FIG. 1. Daily milk yields obtained from identical twins milked by machine compared with their mates which were nursing their calves until vealing age.

weeks. In four pairs the suckled twin equaled the milked twin in production at the fourth, fourth, seventh, and tenth weeks, respectively, after vealing. In one pair the milked twin produced consistently higher than the suckled one beyond 20 weeks after vealing, and in another the suckled twin consistently exceeded the milked twin in production the second week after vealing. The higher the production of the heifers, the longer the time required for the twins to reach equal production. Milking the heifers after the calf nursed produced some extra milk during the nursing period, but it did not prevent the subnormal production for 6 weeks after cessation of nursing. The average fat tests of the milk while both twins were being milked after vealing the calves are plotted in Figure 2.

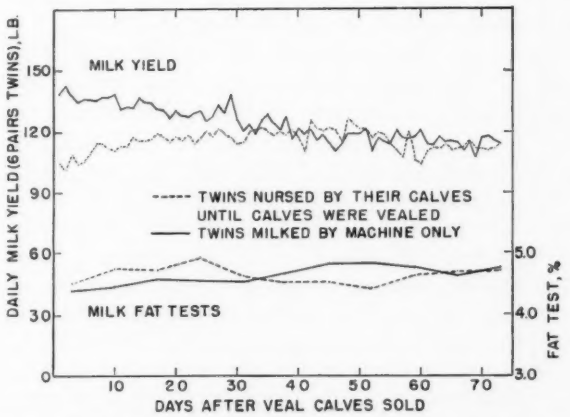

FIG. 2. Daily milk yields and weekly fat tests of previously nursed twins compared to their milked identical mates after their calves had been sold and nursing stopped.

The previously nursed heifers had slightly higher fat tests than their mates during the first weeks while they were producing lower. This result does not indicate incomplete milking, and the appearance and feel of the udders after milking also indicated that the twins were milked with equal efficiency.

The average loss in milk due to nursing has been summarized by different periods in Table 1. The total production in this experiment was 1,496 lb. of milk, which averaged 4.66% fat, or an equivalent of 1,644 lb. of fat-corrected milk (FCM). The amount lost during the nursing period was 92.9% of the total.

TABLE 1

Milk production comparisons at different periods of milked and nursed identical twin heifers (average of six comparisons)

Time	Milked	Nursed	Difference
	(lb.)	*(lb.)*	*(lb.)*
Until vealing age of nursed calves (av. 65.3 days)	1,536	146	1,390
From vealing age to 17th wk. of lactation (av. 53.7 days)	1,200	1,100	100
From 17th to 20th wk. of lactation (21 days)	398	392	6
Complete lactation to 20th wk. (140 days)	3,132	1,638	1,496

The weekly milk production of the twins for 10 weeks after the calves had been sold is presented in Table 2. The differences between the milked and nursed twins were greatest in the first week when they averaged, respectively, 22.9 and 17.8 lb. of milk daily. The nursed twins then gradually increased in milk yield to the seventh week while the milked twins gradually declined. After the fifth week the two groups milked almost equally. The data in Table 2 were subjected to analysis of variance. For the first 5 weeks it was found that the yield differences due to treatment were very highly significant statistically. Highly significant differences were also noted between twin pairs, but not between weeks. Highly significant interactions between treatments and pairs and between treatments and weeks were also found. Some of the pairs had greater initial yield differences than others, and there were differences in the rate at which they returned to equal production. Differences due to treatments in the last 5 weeks were not significant. The only statistically significant differences in the last 5 weeks were between pairs and the pair × treatment interaction.

A summary of the average calf data from this experiment is presented in Table 3. Each calf group consisted of four males and two females. One very large nursed calf, weighing 95 lb. at birth, accounted for all of the average birth weight difference between groups, since the other pairs' calves were very close in birth weights. A slight illness afflicted one calf in each group. One fed calf had a short attack of diarrhea, and one nursed calf had an asthmatic condition which affected it on hot days. Since these conditions seemed to offset each other, data for all calves are included in the average calculations. The nursed calves gained slightly faster than the fed calves and graded about one-half grade higher both at the time of selling and in the final carcass grade. This difference was undoubtedly due to a greater intake of milk by the nursed calves. It would have been possible for them to have had 1,390 lb. (Table 1); but they probably con-

TABLE 2

Weekly milk production of pairs of identical twins beginning after veal calves were sold, comparing twins that had been milked only since calving with their mates that had been nursed

Twin No.	Treatment	Weeks after calves were vealed										Totals	
		1	2	3	4	5	6	7	8	9	10	1-5 wk.	6-10 wk.
		(lb.)											
6-1	Milked	179.6	175.3	183.1	186.7	176.6	169.4	137.3	159.9	160.7	150.0	901.3	777.3
5-1	Nursed	139.4	148.4	159.1	153.7	145.9	158.4	161.5	150.6	155.6	153.0	746.5	779.1
3-1	Milked	84.2	96.0	77.1	61.5	58.9	57.1	61.2	58.0	58.5	62.5	377.7	297.3
4-1	Nursed	53.7	55.7	58.7	69.1	72.4	70.6	79.1	74.6	65.4	51.6	309.6	341.3
28	Milked	115.6	117.8	110.2	105.4	114.6	110.2	113.9	101.1	102.2	110.3	563.6	537.7
27	Nursed	80.0	89.6	102.5	107.9	112.8	97.2	106.2	111.0	105.6	122.5	492.8	542.5
9	Milked	196.7	190.1	192.7	193.8	186.1	181.3	184.0	183.7	171.5	164.2	959.4	884.7
10	Nursed	149.7	153.1	143.7	144.4	147.5	143.1	140.7	145.6	138.3	148.6	738.4	716.3
5-2	Milked	245.2	237.3	231.8	237.3	224.5	216.1	196.7	189.1	203.7	198.4	1176.1	1004.0
6-2	Nursed	197.8	208.2	206.8	212.0	201.5	202.3	199.5	184.3	177.3	189.4	1026.3	952.8
3-2	Milked	140.2	130.6	124.0	123.7	125.3	120.2	121.4	128.9	123.1	113.9	643.8	607.5
4-2	Nursed	128.3	144.0	149.9	142.4	153.1	164.0	165.9	159.0	141.4	124.9	717.7	755.2
Av.	Milked	160.2	157.9	153.2	151.4	147.7	142.4	135.7	136.8	136.6	133.2	154.1	136.9
Av.	Nursed	124.8	133.2	136.8	138.3	138.9	139.3	142.2	137.5	130.6	131.7	134.4	136.2

TABLE 3

Data relating to the feeding, growth, and marketing of veal calves from six pairs of identical twin cows

	Nursed	Fed
Birth weight *(lb.)*	71.2	69.5
Veal weight *(lb.)*	194.3	190.3
Total gain *(lb.)*	123.2	120.8
Days fed	65.3	66.7
Gain per day *(lb.)*	1.93	1.82
Selling price *(cents/lb.)*	21.3	20.0
Selling grade, av.	High good	Low good
Carcass grade, av.	High good	Low good
Dressing percentage, wet	68.9	66.5
Dressing percentage, cooled, skinned	57.8	54.7
Milk lost or fed to calf *(lb.)*	1,496	1,179
Sales value of calf *(dollars)*	41.80	38.24
Return per cwt. milk *(dollars)*	2.79	3.23[a]

[a] An average of 21¢ worth of calf starter (4.67 lb.) consumed per calf was deducted from calf value before calculating return from milk.

sumed less than that, yet more than the 1,179 lb. fed to their mates. In spite of the higher price for the suckled veal, the return per hundredweight for milk was 44 cents lower by that vealing method than by feeding the calves a rationed amount.

DISCUSSION

The results of this experiment indicate clearly that cows nursing their calves for an extended period do not give as much milk as those that have been milked without nursing. Possible explanations for this effect are: *(a)* During the nursing period the calf does not milk the cow as completely as does the milker, and the retention of milk causes a reduction of activity or cessation of secretion from part of the mammary glands, and *(b)* having become accustomed to the nursing and being attached to the calf, the cow would not respond to machine milking with a normal reflex to produce a full let-down of milk. If the latter explanation were very important, other indications of incomplete let-down, such as a lower fat test and noticeable retention of milk in the udders, should have been observed. Since these were not noticeable except for the first day or two after weaning, the second explanation is probably unimportant in this experiment. The fact that cows that were milked after each nursing showed about the same lowered production as those not milked was not expected. However, two of the three heifers handled this way gave very little milk and varied widely from milking to milking at the post-nursing milkings. This indicated that they were not responding to such milkings with a normal let-down; thus, they could have been retaining in their udders considerable milk that normally would have been secured. The inability to obtain satisfactory milk let-down in cows at short milking intervals has been noted before *(7, 9, 10)*. The depressing effect of incomplete milking upon lactation has long been recognized and has been shown very clearly by Donker and Petersen *(2)* in an experiment with identical twin cows. All but one of the nursed cows recovered fully from the milk-reducing effect of nursing by the middle of lactation, and the depressing action could be reversed by later complete milkings to bring the milk yield to normal.

The economics of the two methods of veal production is not entirely expressed by the difference in return for milk. On farms with a labor shortage the cost of milking the cow and feeding the calf must be deducted from the fed-calf return unless the cow was milked after nursing. In that instance there would be no real saving of labor. The difference in grades of veal could very probably have been prevented by feeding the calves ad lib. with nipple pails, as was done in a veal production experiment by Hopper *et al. (6)*. Calves nursing the same quantity of milk from a bucket as from an udder should gain as well on one as the other. The main economic difference with equal calf consumption and equal veal returns could be, therefore, the net loss of milk production due to suckling. This averaged 106 lb. of 4.66% milk in the 10 weeks after vealing and undoubtedly amounted to an equal amount unobtainable during the nursing period of 9 weeks. This loss, an estimated 200 to 250 lb. of milk, can be offset only by the labor saving resulting from not feeding the calf.

SUMMARY

Four pairs of identical twin heifers of the Jersey and Guernsey breeds were used in six lactation periods to compare the production of heifers milked in the usual manner with that of heifers that nursed their calves until they were of vealing size. Milk production in the first week after vealing averaged 5.1 lb. per cow per day lower in the nursed group than in the milked group. Lactation of the nursed groups increased gradually after vealing until at 6 weeks the groups were producing equally. The total loss of milk due to the calf nursing averaged 1,496 lb. per cow.

ACKNOWLEDGMENT

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THE ESTROGENIC ACTIVITY OF LEGUME, GRASS, AND CORN SILAGE[1]

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It has long been known that pastures vary widely in their ability to maintain high milk production. It has also been recognized that pasture may actually stimulate mammary function (galactopoietic effect) and may improve reproductive efficiency. These desirable properties of forage have been explained in terms of a variety of factors, such as species of plant, stage of growth, seasonal and climatic effects, and protein, vitamin, and fiber content.

Since the report of Loewe and Spohr *(6)* of the presence of estrogenic activity in the plant kingdom, the estrogen content of many plant materials has been investigated. More than 50 species, including such plants as alfalfa; red, white, and subterranean clover; oats; and rye, have been shown to have estrogenic activity. Bennetts *et al. (2)* showed that Australian subterranean clover grazed by sheep contained sufficient estrogenic activity to bring about extensive genital and mammary development and to adversely affect reproduction.

Because of the known effects of a natural estrogen, estradiol, in increasing the nonfatty solids of milk *(4)*, it was logical to investigate the galactopoietic effects of pasture in terms of estrogen content *(1)*.

Although the presence of estrogens in plants and their correlation with galactopoiesis have not yet been clearly established, it was considered desirable to investigate the estrogenic activity of a variety of feedstuffs. The estrogenic activity of legume, grass, and corn silage is reported in this paper, and the hormonal activity of certain pastures, hays, and feed grains is reported elsewhere by Pieterse and Andrews *(7)*.

EXPERIMENTAL PROCEDURE

All plant materials were dehydrated in a plant dryer at 170° F. for 24-48 hours to a moisture content of 6-9%. A 350-g. sample of dried ground material was refluxed for 1 hour in 1,400 ml. of 95% ethanol. After cooling, the alcoholic extract was removed by filtration and the plant residue was extracted a second time with 1,400 ml. of fresh ethanol for 1 hour. The two extracts were combined and concentrated under partial vacuum and heating in a water bath to approximately 300 ml. This alcoholic concentrate was mixed with 300 g. of a standard laboratory mouse ration, and the alcohol was allowed to evaporate. The weight of the test sample was adjusted to 350 g. by the addition of the standard mouse ration in order that 1 g. of the test ration would represent 1 g. of the original plant material extracted. The test ration was then fed to castrated female mice

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of the Rockland Swiss strain at the rate of 3 g. per mouse per day for 10 days. Twenty-four hours after the last feeding, the mice were weighed and sacrificed. The uteri were removed, slit lengthwise, blotted between filter paper to remove free moisture, and weighed. Each assay trial included a control group of ovariectomized mice fed only the standard laboratory ration. The data were treated by the analysis of variance *(9)*.

RESULTS AND DISCUSSION

The first alfalfa silage sampled was prepared by the direct cut method from first-cutting alfalfa in tenth bloom in the spring of 1953. It was conditioned with approximately 80 lb. of blackstrap molasses per ton of green material and stored in an upright steel silo. The silage was sampled for assay in the winter of 1954. As shown in Table 1, it contained appreciable estrogenic activity. In

TABLE 1

Estrogen assay of alfalfa silage and freshly cut alfalfa

Group Treatment	1 Control	2 Alfalfa silage	3 Control	4 Alfalfa pasture
No. of mice	8	8	9	10
Mean body wt. *(g.)*	25.0	22.8	24.1	24.6
Mean uterine wt. *(mg.)*	16.9 ± 1.5	85.0 ± 5.2[a]	16.8 ± 0.4	22.2 ± 0.9[a]
Per cent body wt.	0.067	0.375[a]	0.070	0.091[a]
Av. feed consumption *(g.)*	43.3	20.6	26.2	26.4
Estimated potency *(γ stilbestrol/lb dry matter)*	—	30.5	—	< 0.5

[a] $P < 0.01$.

the spring of 1954, samples of alfalfa in tenth bloom were taken from the field from which the silage had been made. This fresh alfalfa was dried in a plant drier, as previously described, and assayed. Although the sample was estrogenic, its activity was not at all comparable to that of the silage (Table 1), and the question was raised as to whether the process of ensiling might increase the estrogenic activity in alfalfa.

Five different silage samples were then compared. The assay data are summarized in Table 2. The alfalfa silage in Group 2 was taken from the same silo as that reported in Table 1. The sample was taken 3 weeks after the first and was therefore closer to the bottom of the silo. The estrogenic activity of this sample was estimated to be equivalent to 35.1 γ of diethylstilbestrol per pound of dry matter and was the most estrogenic of any feed sample included in this study. The silage sample in Group 3 was grown on a field adjacent to that of Group 2 and was a mixture of alfalfa and brome grass. It was also preserved with 80 lb. of molasses per ton of green material. The corn silage in Group 4 had been harvested in the dent stage while the leaves were still green, and that of Group 5 was described to us as "immature." The brome grass silage was cut when the seed heads were beginning to form and was ensiled without a preservative. It is apparent that of the five samples only those containing alfalfa were estrogenic.

TABLE 2

Assay of silages prepared from alfalfa, alfalfa–brome grass, brome grass, and corn

Group	1	2	3	4	5	6
Treatment	Control	Alfalfa silage	Alfalfa brome silage	Corn silage	Corn silage	Brome grass silage
No. of mice	10	10	10	10	10	10
Mean body wt. *(g.)*	23.8	25.3	26.2	25.8	24.2	24.2
Mean uterine wt. *(mg.)*	16.2 ± 0.7	100.4 ± 4.6[a]	80.6 ± 5.5[a]	16.7 ± 0.9	16.8 ± 1.2	16.4 ± 0.5
Per cent body wt.	0.068	0.398[a]	0.310[a]	0.065	0.070	0.068
Av. feed consumption *(g.)*	23.8	17.9	20.2	24.0	20.4	23.2
Estimated potency *(γ stilbestrol/lb dry matter)*	—	35.1	25.3	—	—	—

[a] $P < 0.01$.

In order to gather further information as to the estrogenic activity at different levels of the same silo, samples were taken from the top unspoiled layers and near the bottom. This alfalfa silage had been preserved with 150 lb. of ground ear corn and 100 lb. of corncobs per ton of freshly chopped green material. The silage had been stored for approximately 24 months at the time the silo was opened. The data, summarized in Table 3, suggest that the estrogenic activity was greater at the bottom.

TABLE 3

Assay of alfalfa silage from the top and bottom of an upright silo

Group Treatment	1 Control	2 Alfalfa silage from top of silo	3 Control	4 Alfalfa silage from bottom of silo
No. of mice	9	9	9	9
Mean body wt. *(g.)*	22.3	22.8	24.1	23.7
Mean uterine wt. *(mg.)*	16.8 ± 1.1	50.0 ± 7.3[a]	16.8 ± 0.4	72.6 ± 2.7[a]
Per cent body wt.	0.075	0.222[a]	0.070	0.300[a]
Av. feed consumption *(g.)*	30.0	26.6	26.2	24.4
Estimated potency *(γ stilbestrol/lb dry matter)*	—	8.0	—	14.7

[a] $P < 0.01$.

Because of the possibility that the estrogenic activity of alfalfa increases during fermentation, 25 lb. of freshly cut alfalfa was packed into each of three 5-gal. tins. One sample was preserved with molasses at the rate of 80 lb. per ton of green forage, one was preserved with 200 lb. of ground corn per ton, and the third contained no preservative. A sample of fresh alfalfa was prepared in the usual way at the time the silage was made. After 5 months of storage, the tins were opened. The surface material was decomposed and was discarded. The samples taken for assay appeared to be reasonably typical of a large silo.

The freshly cut alfalfa (Table 1, Group 4) produced a mouse uterine weight of 22.2 ± 0.9 mg., as compared to the activity shown in Table 4. These data suggest that the estrogenic activity of alfalfa is increased after ensiling.

Further evidence that estrogenic activity may increase after ensiling is presented in Table 5. The material ensiled was a mixture of alfalfa, ladino

TABLE 4

Assay of alfalfa silages stored in miniature silos

Group Treatment	1 Control	2 Silage stored without a preservative	3 Molasses preserved silage	4 Silage preserved with ground corn
No. of mice	20	10	10	10
Mean body wt. *(g.)*	24.5	25.2	23.9	25.7
Mean uterine wt. *(mg.)*	18.2 ± 0.6	29.2 ± 1.1[a]	47.3 ± 2.2[a]	27.5 ± 1.8[a]
Per cent body wt.	0.076	0.117[a]	0.198[a]	0.107[a]
Av. feed consumption *(g.)*	28.1	24.9	23.8	23.2
Estimated potency *(γ stilbestrol/lb dry matter)*	—	1.4	—	1.1

[a] $P < 0.01$.

TABLE 5

Assay of a mixture of alfalfa, ladino clover and brome grass, artificially dehydrated and stored in steel upright silos

Group Treatment	1 Control	2 Grass mixture assayed without storage	3 Grass mixture stored at 10° C.	4 Grass silage preserved with sodium metabisulfite	5 Grass silage preserved with molasses
No. of mice	10	9	10	10	10
Mean body wt. *(g.)*	27.4	23.8	27.4	29.3	27.6
Mean uterine wt. *(mg.)*	16.7 ± 0.7	19.2 ± 1.9	19.0 ± 0.5	36.8 ± 1.8[a]	33.1 ± 2.4[a]
Per cent body wt.	0.061	0.080	0.070	0.126[a]	0.120[a]
Av. feed consumption *(g.)*	28.5	25.2	26.3	23.7	24.8
Estimated potency *(γ stilbestrol/lb dry matter)*	—	—	—	4.4	2.7

[a] $P < 0.01$.

TABLE 6
Dose-response assay with oral diethylstilbestrol

Total dose stilbestrol per animal	No. of mice	Mean uterine weight
(γ)		*(mg.)*
None	39	16.9 ± 0.8
0.027	10	22.0 ± 1.2
0.1	20	24.8 ± 1.1
0.2	20	35.3 ± 3.3
0.4	20	44.1 ± 3.7
0.6	10	59.8 ± 3.7
0.8	19	84.2 ± 6.1
1.6	17	104.0 ± 6.5

clover, and brome grass (60, 15, and 25%, respectively). A sample was taken at the time of harvesting; it was dried and ground in the usual manner. One portion was prepared for immediate assay and a second portion was stored in the dry state at 10° C. for 7 months and assayed simultaneously with the silage samples. One upright silo contained the alfalfa–ladino–brome grass mixture preserved with 8 lb. of sodium metabisulfite per ton of green material, and a second silo contained the same mixture preserved with 20 lb. of blackstrap molasses per ton of green material. As shown in Table 5, there is excellent agreement between the estrogenic activity of the original sample and that of the same material after 7 months of storage in the dry state (Groups 2 and 3). It is likewise clear that the ensiled mixture, whether preserved with sodium metabisulfite or molasses, showed a considerable increase in activity.

The estrogenic activity of the silage samples can be estimated by reference to Table 6 or Figure 1. These data were obtained by the addition of known amounts of diethylstilbestrol to the standard laboratory mouse ration. The rations were fed to ovariectomized mice at the rate of 2 g. per mouse per day for 10 days.

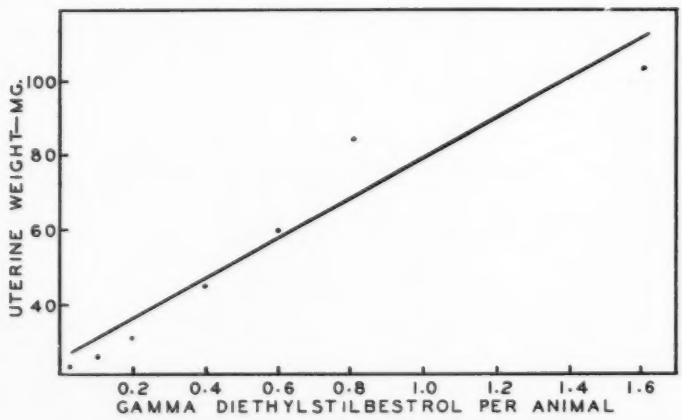

FIG. 1. Dose-response curve for diethylstilbestrol.

TABLE 7

Assay of orally administered genistein with and without prior treatment with mild alkali

Group	1	2	3	4	5	6
Total dose/animal genistein *(mg.)*	None	2.5	5.0	10.0	20.0	Genistein treated with mild alkali 10 mg. equivalent
No. of mice	10	10	10	10	10	10
Mean body wt. *(g.)*	24.7	25.1	25.7	26.4	25.5	24.9
Mean uterine wt. *(mg.)*	19.5 ± 0.6	21.1 ± 1.3[a]	22.0 ± 0.9[a]	22.5 ± 0.8[a]	30.0 ± 0.8[a]	33.0 ± 1.7[a]
Per cent body wt.	0.080	0.084	0.086	0.085	0.118[a]	0.133[a]
Estimated potency *(γ stilbestrol: 1 γ genistein)*	—	—	—	3.75×10^{-6}		1.6×10^{-5}

[a] $P < 0.01$.

If the estrogenic activity of alfalfa or other forages is increased after ensiling, it seems logical to assume either that an estrogen, or estrogens, present at the time of harvest becomes more potent or that a new estrogenic substance is produced during fermentation. No attempt was made in this study to determine the chemical nature of the estrogens present. Chemical studies by others indicate that most of the estrogenic activity of pasture plants is contributed by isoflavone compounds *(8)*. One of these substances, genistein, has been shown by Biggers and Curnow *(3)* to be a pro-estrogen, which is converted to a true estrogen within the body. According to Gisvold *(5)*, treatment of isoflavones with mild alkali may produce benzyl-*o*-hydroxyketone. Whether this compound is estrogenic is not known, but its structural resemblance to such well known estrogenic diphenylethane derivatives as dienestrol and hexestrol is suggestive.

A single approach to the problem was the refluxing of genistein for 1 hour in a 1.5% potassium hydroxide solution of 95% ethanol. As shown in Table 7, the estrogenic activity of 10 mg. of genistein per mouse was increased from 3.75×10^{-6} to 1.6×10^{-5} times that of diethylstilbestrol.

If some isoflavones are converted in the body to diphenylethane derivatives it may be that substances present in plants at the time of ensiling are converted to more potent estrogens during fermentation.

SUMMARY

The estrogenic activities of alfalfa pasture, alfalfa, brome grass, and corn silages, and mixtures of alfalfa, ladino, and brome grass silages with and without preservative were compared.

The estrogenic activity of alfalfa silage was significantly greater than that of freshly cut alfalfa. Corn or brome grass silages did not contain significant estrogenic activity. A mixture of alfalfa, ladino clover, and brome grass silage increased in estrogenic activity during fermentation in steel upright silos with either sodium metabisulfite or molasses as a preservative.

The estrogenic activity of alfalfa silage at the top of an upright silo was less than at the bottom. When alfalfa silage was prepared in 5-gal. tins, the greatest estrogenic activity occurred in the sample preserved with molasses. There was little difference in activity between the silage without preservative and that in which ground corn was used. All three silages contained significantly more estrogenic activity than the fresh alfalfa.

The estrogenic activity of the isoflavone genistein was significantly increased by the treatment of genistein with a 1.5% potassium hydroxide solution of 95% ethanol.

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DILUTERS FOR BOVINE SEMEN. VII. EFFECTS OF TIME AND TEMPERATURE OF HEATING SKIMMILK UPON THE LIVABILITY OF BOVINE SPERMATOZOA[1, 2]

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Earlier studies at this laboratory *(1, 2, 15)* and others *(6, 7, 12, 16)* have shown that fresh homogenized milk and skimmilk can be used as satisfactory diluents for bovine semen provided the milk is heated and cooled prior to semen dilution. However, Bolton and Durrell *(3)* found heated skimmilk to be inferior to egg yolk–citrate. Varying results have been reported by several artificial breeding organizations *(14)*. A review of the latter reports indicated that a wide range of heating procedures was employed in the preparation of the milk diluents.

Michajilov *(12)* suggested that milk should be brought to a boil before it is cooled, whereas Thacker and Almquist *(15)* found that milk heated at 95° C. for 1 to 10 minutes supported optimum spermatozoan livability.

The objective of the present laboratory study was to determine the effect of the time and temperature of heating skimmilk upon its ability to support spermatozoan livability.

EXPERIMENTAL PROCEDURE AND RESULTS

Fresh pasteurized skimmilk was obtained from the University Creamery approximately 24 hours prior to its use. Freshly prepared egg yolk–citrate (1:1) served as the control, and all semen samples were diluted at the rate of 15×10^6 motile sperm per milliliter. Streptomycin was added to the heat-treated milks and the egg yolk controls at the rate of 1,000 units per milliliter of diluent. The diluted semen was stored for 14 days at 5° C.

Experiment 1. In this experiment, skimmilk was heated rapidly (see Figure 1) to temperatures of 73°, 81°, 89°, 97°, and 105° C. Rapid heating was employed in an attempt to overcome the cumulative effects of gradual heating. Portions of skimmilk were held at each of these temperatures for periods of 3, 9, and 27 minutes.

The rapid heating was accomplished as follows: 30-ml. samples of skimmilk were pipetted into 50-ml. cork-sealed centrifuge tubes. Four tubes were heated simultaneously from 25° C. to one of the treatment temperatures by placing them in a wire basket and immersing the basket in a preheated, 170° C. paraffin-

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[2] The data contained in this paper are part of a thesis submitted by the senior author to the Graduate School of The Pennsylvania State University in partial fulfillment of the requirements for the degree of Master of Science.

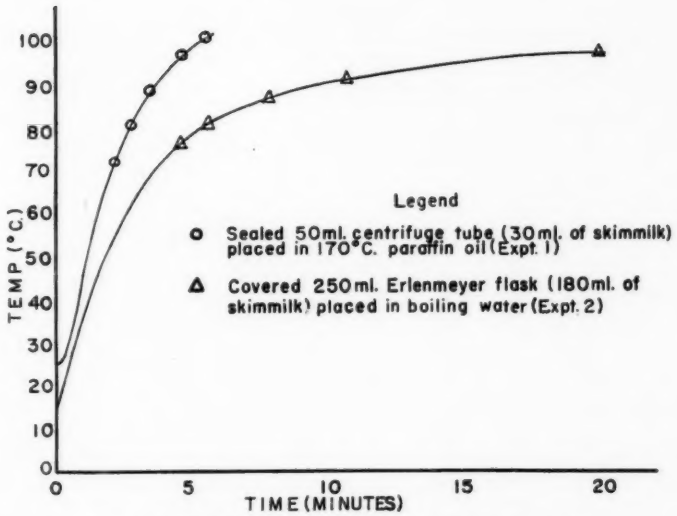

FIG. 1. Rates of heating skimmilk in Experiments 1 and 2.

oil bath. Temperature was recorded from a nonexperimental 30-ml. sample of skimmilk. Upon reaching the treatment temperature, the tubes were passed through a 10° C. water bath, which served to arrest the rapidly rising temperature at the desired level, and placed in a mechanical water bath maintained at the treatment temperature. An oil bath was used for the 105° C. heat treatment. At the end of each holding period (3, 9, and 27 minutes) one tube was cooled rapidly in an 8° C. water bath.

The mean percentages of motile spermatozoa during 14 days of storage are presented in Table 1. Each figure represents the mean for 12 ejaculates. Four lots of skimmilk were involved and each lot was used for diluting three ejaculates.

An analysis of variance involving 1,620 motility estimations for the heated skimmilk showed a highly significant time-temperature interaction ($P < 0.01$). Neither time nor temperature alone was significant when the time-temperature interaction was used as the error term for calculating the "F" values for time and temperature.

There were no significant differences in the livability of spermatozoa diluted in skimmilk heated from 73° C. to 97° C. for 27 minutes, or from 81° to 105° C. for 3 or 9 minutes. Skimmilk heated to 73° C. for 3 minutes was highly significantly poorer than that subjected to the other heat treatments ($P < 0.01$), and skimmilk heated to 73° C. for 9 minutes was significantly inferior to all diluents with the exception of skimmilk heated to 73° C. for 3 minutes, 97° C. for 27 minutes, and 105° C. for 3, 9, and 27 minutes ($P < 0.05$). Skimmilk heated to 105° C. for 27 minutes was highly significantly inferior to skimmilk heated to 89° C. for 27 minutes ($P < 0.01$) and significantly inferior to the remaining treatments with the exception of 97° C. for 27 minutes and 73° C. for 3 and 9

TABLE 1

Livability of spermatozoa in skimmilk heated to various temperatures for 3, 9, and 27 minutes (mean of 12 ejaculates)

Temperature of heat treatment	Holding time	Per cent motile spermatozoa after storage at 5° C. for								
		1 day	2 days	3 days	4 days	6 days	8 days	10 days	12 days	14 days
(° C.)	*(min.)*									
73	3	17	4	1	0					
	9[a]	50	49	43	39	32	20	15	8	4
	27	65	63	60	52	41	26	18	7	3
81	3	63	61	58	51	43	27	20	10	4
	9	63	60	60	53	45	32	16	8	4
	27	63	62	58	52	40	23	17	8	3
89	3	63	62	57	53	42	31	18	7	3
	9	63	60	57	51	40	26	19	6	3
	27	65	60	60	52	44	30	19	10	4
97	3	65	61	58	52	42	28	17	8	4
	9	62	61	59	52	38	27	17	10	3
	27	63	60	57	49	42	21	11	5	2
105	3	62	58	58	48	40	27	17	7	2
	9	63	62	57	50	40	24	14	6	2
	27	63	63	53	44	25	8	2	0	
Unheated skimmilk		0								
Egg yolk–citrate (1:1)		64	59	54	52	43	33	25	18	13

[a] One lot of skimmilk did not respond favorably to this heat treatment.

minutes ($P < 0.05$). These data show that heating time was important in obtaining optimum spermatozoan livability only when skimmilk was heated at 73° and 105° C.

To compare the livability of spermatozoa in egg yolk–citrate to that in any one of the heat-treated skimmilks, the highest order interaction involving storage obtained in the analysis of the heat-treated skimmilks (storage intervals × temperatures) was combined with the ejaculates × storage intervals interaction for the egg yolk–citrate diluent to estimate a least significant difference between the yolk-citrate and any one of the skimmilk treatments. This analysis showed that there was no significant difference between the livability of spermatozoa in the two diluents when skimmilk was subjected to heat treatments ranging from 73° C. for 27 minutes to 97° C. for 9 minutes, or when skimmilk was heated to 105° C. for 3 minutes. Egg yolk was significantly superior to skimmilk subjected to heat treatments of 73° C. for 3 and 9 minutes, 105° C. for 27 minutes ($P < 0.01$), 97° C. for 27 minutes, and 105° C. for 9 minutes ($P < 0.05$).

Table 2 shows the mean per cent livability of spermatozoa for the four lots of skimmilk heated to 73° C. for 3, 9, and 27 minutes, and unheated. It is apparent that the differences in spermatozoan livability among lots of skimmilk heated to 73° C. for 3 minutes or 73° C. for 9 minutes were associated more with variations among lots of skimmilk than with variations among ejaculates. The inferior livability of spermatozoa in skimmilk heated to 73° C. for 9 minutes (footnote, Table 1) was due to one lot which did not respond favorably to that heat treat-

TABLE 2

Differences among lots of skimmilk in their response to time and temperature

Lot of skimmilk	Ejaculate	Unheated skimmilk	Mean livability of spermatozoa during 14 days of storage at 5° C. in skimmilk heated to 73° C. for		
			3 min.	9 min.	27 min.
1	1	0	0	1	37
	2	0	0	4	36
	3	0	0	0	34
2	4	0	6	33	32
	5	0	4	39	38
	6	0	3	42	44
3	7	0	7	43	42
	8	0	6	36	38
	9	0	3	39	37
4	10	0	0	35	42
	11	0	0	37	33
	12	0	0	38	33

ment (Lot 1, Table 2). Lots 2 and 3 showed slight signs of detoxification after heating to 73° C. for only 3 minutes.

Experiment 2. Based upon the results obtained with the rapid heating of skimmilk in Experiment 1, a second trial was conducted to establish a more practical heating procedure (the heating rate is shown in Figure 1). In this experiment, fresh pasteurized skimmilk was heated to 77°, 82°, 87°, 92°, and 97° C. for 1 and 10 minutes. The heating procedure was as follows: two 180-ml. aliquots of skimmilk at 10° C. were heated simultaneously in 250-ml. Erlenmeyer flasks placed in a boiling water bath. A rubber stopper placed in the top of the Erlenmeyer flask contained two holes to allow for the insertion of a thermometer and a 5-inch piece of glass tubing. The glass tubing prevented the accumulation of pressure during heating and at the same time served as a reflux condenser, thus keeping water loss at a minimum.

When the skimmilk reached the desired temperature, the flasks were removed and placed in a second bath, which maintained the temperature for the duration of the holding period. At the end of each holding period (1 and 10 minutes) one flask of skimmilk was cooled rapidly by placing it in a 10° C. water bath.

The mean percentages of motile spermatozoa during 14 days of storage are presented in Table 3. Each figure represents the mean for 10 ejaculates. Two lots of skimmilk were involved and each lot was used for diluting five ejaculates.

An analysis of variance involving 900 motility observations for heated skimmilk showed no significant difference among temperatures or holding times; however, as in Experiment 1, the time-temperature interaction was highly significant ($P < 0.01$).

Skimmilk heated for 1 minute at temperatures ranging from 87° to 97° C. or for 10 minutes at temperatures ranging from 77° to 97° C. supported optimum spermatozoan livability without any significant differences among treatments. Skimmilk heated to 77° C. for 1 minute was highly significantly inferior to any of the other heat-treated skimmilks ($P < 0.01$). Skimmilk heated to 82° C. for

TABLE 3

Livability of spermatozoa in skimmilk heated to various temperatures for 1 and 10 minutes (mean of 10 ejaculates)

Temperature of heat treatment	Holding time	Per cent motile spermatozoa after storage at 5° C. for								
		1 day	2 days	3 days	4 days	6 days	8 days	10 days	12 days	14 days
(° C.)	*(min.)*									
77	1	0	0							
	10	59	53	50	44	33	15	5	3	1
82	1[a]	48	32	28	20	15	2	0	0	
	10	60	54	48	40	28	9	3	0	0
87	1	60	53	51	39	30	12	5	3	1
	10	56	54	49	40	30	8	4	1	0
92	1	61	53	47	40	31	13	6	1	1
	10	60	58	48	38	34	12	7	0	0
97	1	60	53	50	36	32	11	6	1	1
	10	60	52	45	34	23	7	2	1	0
Egg yolk-citrate (1:1)		57	54	47	42	35	21	14	7	5

[a] One lot of skimmilk did not respond favorably to this heat treatment.

1 minute was highly significantly inferior to the remaining heat treatments ranging from 77° C. for 10 minutes to 97° C. for 1 minute ($P < 0.01$) and significantly inferior to the 97° C. for 10 minutes treatment ($P < 0.05$).

A statistical comparison of spermatozoan livability in the yolk-citrate control and in each of the heat-treated skimmilks was conducted in the same manner as in Experiment 1. This analysis showed that there was no significant difference between the two diluents when skimmilk was heated for 1 minute at temperatures ranging from 87° to 97° C. or for 10 minutes at temperatures ranging from 77° to 92° C. The yolk-citrate control was significantly superior to skimmilk subjected to heat treatments of 77° C. for 1 minute, 82° C. for 1 minute ($P < 0.01$), and 97° C. for 10 minutes ($P < 0.05$).

In both experiments the livability of spermatozoa in egg yolk–citrate was higher than that in heated skimmilks after 6 days of storage (Tables 1 and 3).

DISCUSSION

These results demonstrate that spermatozoan livability in fresh pasteurized skimmilk is dependent upon the time and temperature of the heat treatment to which the skimmilk is subjected.

In Experiment 1, the time of heating was discriminative to optimum spermatozoan livability only when skimmilk was heated at 73° and 105° C. To obtain optimum spermatozoan livability by heating skimmilk at 73° C., a prolonged holding time was required (27 minutes), but prolonged heating at 105° C. (27 minutes) resulted in poor spermatozoan survival. Skimmilk heated to temperatures within these extremes maintained optimum spermatozoan livability irrespective of the heating time employed. Thus the highly significant time-temperature interaction was accounted for by the 73° and 105° C. heat treatments. A

similar situation was found in Experiment 2, in which heating time was important only when the skimmilk was heated at 77° and 82° C. Skimmilk heated from 87° to 97° C. supported optimum spermatozoan livability after heating for either 1 or 10 minutes.

The beneficial effect of heat upon milk has been demonstrated to be the result of the inactivation of lactenin *(8)*, an antistreptococcal, spermicidal factor that is active in unheated milks. Johnson *et al. (9)* have postulated that lactenin is inactivated by active sulfhydryl groups originating from the heat denaturation of beta-lactoglobulin. Since beta-lactoglobulin undergoes rapid denaturation in milk heated at approximately 75° to 82° C. *(11)* and the present time-temperature studies show that skimmilk is detoxified within this temperature range, these data provide further evidence that the postulate of Johnson *et al.* is essentially correct. Also to be considered is that lactenin itself is inactivated by heat treatments above 80° C. *(10)*.

If the detoxification of milk diluents is dependent upon the denaturation of beta-lactoglobulin and subsequent activation of SH groups, the differences in the time and temperature required to render different lots of skimmilk nontoxic to spermatozoa may be the result of differences in the resistance of their proteins to heat denaturation *(1)*, variations in their SH content *(11)*, or the cumulative effect which previous heat treatments have upon subsequent heat treatments *(11)*.

The detrimental effects of prolonged heating at high temperatures on spermatozoan livability, as displayed by skimmilk subjected to 105° C. for 27 minutes in Experiment 1, may be associated with the browning of milk and the subsequent loss of SH groups or the accumulation of new heat-generated products, such as volatile acids, furfuryl alcohol, ammonia, or maltol. However, there is no evidence that poor spermatozoan livability is associated with browning or the accumulation of any one of the mentioned products.

Factors which may influence the effects of the time and temperature of heating milk upon spermatozoan livability are the uniformity of heating, the volume of milk heated, and the type of vessel employed (open or covered).

From the livability results obtained in Experiment 2, fresh pasteurized skimmilk used for diluting bovine semen should be heated to temperatures ranging from 87° to 97° C. for 1 minute or to temperatures of 82° to 92° C. for 10 minutes. Although skimmilk heated to 77° C. for 10 minutes supported spermatozoan livability (Table 3), this heat treatment is questioned, since certain lots of skimmilk may not respond favorably to this treatment.

SUMMARY

The effect of the time and temperature of heating fresh pasteurized skimmilk upon its ability to support spermatozoan livability during 14 days of storage at 5° C. was studied in two experiments. In both studies there was a highly significant time-temperature interaction.

In the first experiment skimmilk was heated rapidly to various temperatures ranging from 73° to 105° C. for 3, 9, and 27 minutes. Optimum livability was obtained in skimmilk heated to temperatures ranging from 81° to 105° C. for

3 and 9 minutes and 73° to 97° C. for 27 minutes. Heating to 73° C. for 3 and 9 minutes and 105° C. for 27 minutes resulted in significant decreases in livability. Time of heating was important only when the temperature extremes studied (73° and 105° C.) were involved, and thus these treatments accounted for the highly significant time-temperature interaction.

The second experiment was a more practical study in which the heating rate more closely simulated field conditions. Fresh skimmilk was heated to various temperatures, ranging from 77° to 97° C. for 1 and 10 minutes, and optimum livability was obtained with temperatures ranging from 87° to 97° C. for 1 minute and 77° to 97° C. for 10 minutes. Skimmilk heated for 1 minute at 77° and 82° C. resulted in a significant decrease in livability.

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TECHNICAL NOTE

ABSORPTION OF RUMEN VOLATILE FATTY ACIDS FROM THE FORESTOMACHS OF YOUNG DAIRY CALVES FED HIGH ROUGHAGE RATIONS

The relatively small amount of volatile fatty acids (VFA) in the abomasum of adult sheep compared to the amount found in the rumen *(5)* has been shown to be due to direct absorption of acetic, propionic, and butyric acid from the rumen, reticulum, and omasum *(1)*. The volatile fatty acids resulting from rumen fermentation furnish a significant part of the total energy utilized by ruminants *(4)*. It has been shown that young calves fed high roughage rations digested cellulose at an optimum rate and that adult levels of VFA in the rumen were attained during the 5- to 9-week age period *(2, 3)*.

In order to obtain information on the absorption of VFA from the intestinal tract in calves of various ages, VFA was determined at different points along the tract at slaughter.

Five calves ranging from 5 to 15 weeks of age were slaughtered 4 to 6 hours after the morning feeding. Samples of the rumeno-reticular, abomasal, and cecal contents were obtained for VFA determinations. When slaughtered, the calves were consuming from 1 to 5.2 lb. of a pelleted mixture of hay and grain consisting of 2 parts coarsely ground alfalfa hay and 1 part of a simple grain concentrate (Table 1). This ration was fed free choice after 3 days of age. Whole milk feeding had been terminated in four of the calves at 7 weeks of age and thus only one calf was receiving milk at the time of slaughter.

Results obtained by chromatographically separating acetic, propionic, and butyric acid in fluid from the rumeno-reticular, abomasal, and cecal contents are shown in Table 1. These data show the highest concentration of volatile fatty acids in the rumen and the lowest in the abomasum, with a secondary rise occurring in the cecum. It will be noted also that a relatively higher proportion of acetic and a lower proportion of propionic and butyric acid were found in the abomasum and cecum than in the rumen.

The dry matter content of the rumen and abomasum was about equal, yet the concentration of VFA was reduced in the abomasum to 1 to 2% of that in the rumen and reticulum. Thus it is apparent that the VFA were effectively absorbed prior to the digesta entering the abomasum. It is logical to conclude that much of this absorption took place in the omasum. The numerous longitudinal folds and papillae in the omasum *(6)* provide considerable area that should be suitable for absorption and further suggest that this organ has an active absorptive function.

These data indicate that the rumen VFA are nearly completely absorbed from the forestomachs even in young calves and also that the

TABLE 1

Volatile fatty acids in the rumeno-reticular, abomasal, and cecal contents of high roughage fed calves at various ages (meq. per liter)

Calf No.	H 1124	J 1122	J 1120	J 1262	J 1119
Age *(wk.)*	5	10	13	14	15
Feed intake *(lb/d)*	1.0[a]	3.2	5.2	3.7	5.2
Rumen and reticulum:					
Acetic acid	26.1	51.8	37.8	58.7	68.2
Propionic acid	14.3	16.8	13.8	18.1	16.8
Butyric acid	4.0	7.2	10.6	4.9	13.4
Total	44.4	75.8	62.2	81.7	98.4
Abomasum:					
Acetic acid	0.31	0.56	0.65	0.88	0.45
Propionic acid	0.07	0.10	0.16	0.04	0.08
Butyric acid	0.04	0.05	0.09	0.04	0.05
Total	0.42	0.71	0.90	0.96	0.58
Cecum:					
Acetic acid	2.72	3.14	3.02	2.45	3.14
Propionic acid	0.92	0.55	0.40	0.56	0.60
Butyric acid	0.18	0.30	0.21	0.24	0.45
Total	3.82	3.99	3.63	3.25	4.19

[a] Calf H 1124 received 10 lb. of whole milk daily in addition to the pellets.

cecal fermentation serves as a secondary source of VFA.

H. R. CONRAD
J. W. HIBBS
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PEOPLE and EVENTS
in the Dairy Science World

University of Connecticut Prepares to Welcome A.D.S.A. in '56

A.D.S.A. Planning Committee for Annual Meeting

Plans for the 1956 meeting of the A.D.S.A. are being made by Univ. of Connecticut committees. Here steering committee members review plans with PRESIDENT A. N. JORGENSEN. The 1956 meeting will be the Golden Jubilee meeting for the Association and will coincide with the University's Diamond Jubilee year. Left to right are R. E. JOHNSON, chairman of the steering committee; PRESIDENT JORGENSEN; W. B. YOUNG, Dean of the College of Agriculture; MRS. W. A. COWAN, chairman of the women's committee; H. D. EATON, member of the Association's program committee; and W. A. COWAN, head, Dept. of Animal Industries. The meeting will be June 18-21 on the main campus at Storrs.

H. G. Lindquist Dies Suddenly

HARRY G. LINDQUIST of the Univ. of Massachusetts died Dec. 1, 1955, after suffering a heart attack. He was born in Holden, Mass., July 30, 1895.

Professor Lindquist entered the Univ. of Massachusetts in September, 1916. His college education was interrupted by World War I, after which he completed requirements for his B.S. degree in 1922. The M.S. degree was earned in 1924 at the Univ. of Maryland, where he was full time staff member during the following year. Prior to coming to the Univ. of Massachusetts in 1927, he spent 2 years at The Ohio State Univ. as graduate assistant. Professor Lindquist was active in the affairs of the Massachusetts Milk Inspectors' Assoc. and had served as their president and program chairman. He is survived by his widow, two sisters, and a brother.

L. M. Dorsey Passes Away

LLEWELLYN MORSE DORSEY, professor of dairy husbandry and associate dairy husbandman at the Univ. of Maine, died at his home in Orono on Dec. 13. He was born Oct. 13, 1892, at Ellsworth, Maine. Both the B.S. and the M.S. degree were obtained from the Univ. of Maine. Professor Dorsey was active in several professional groups, including the Intern. Assoc. of Milk Sanitarians and the American Society of Refrigerating Engineers, and had been a member of the Maine staff since 1917. He is survived by his widow, Blanche Foster Dorsey.

Dairy Products Improvement Institute to Meet in New York City

The Ninth Annual Meeting of the Dairy Products Improvement Institute, Inc., will be held Feb. 16, 1956, in the west ballroom of the Hotel Commodore, New York City. The meeting this year is of particular significance as it features the work of the Institute and the introduction of its quality control publication, "Requirements for the Sanitary Production of Sweet Cream and Milk for Manufacturing." This is a logical sequel to the Institute's last two annual meetings, when regulatory officials from the Northeast and Midwest presented the regulations under which they operate, particularly as they applied to milk and cream for manufacturing.

The first speaker of the main session in the afternoon will be the Institute's president, W. A. WENTWORTH of The Borden Co., New York City, who will review the history, objectives, and work of the Institute. E. J. ROBERTS of the Breyer Ice Cream Corp., Philadelphia, will discuss the principles and policies underlying the "Requirements for the Sanitary Production of Sweet Cream, and Milk for Manufacturing," and A. C. FAY of H. P. Hood & Sons, Boston, will follow with a discussion of the details of the procedures, standards, and operating requirements presented in the publication. J. A. STALBIRD, chief of the Milk and Restaurant Sanitation Section, New York State Dept. of Health, will present a critical review of the publication, which is in two parts, the general statement, and the operating manual. Copies should be available for distribution at the meeting.

The morning session will be devoted to committee meetings and a general business meeting for members. The afternoon session, which will be particularly interesting to regulatory officials, industry representatives, and people from the educational field, will begin with a

social period and luncheon followed by the presentation of the speakers with President Wentworth presiding.

Hiscock New Head of A.P.H.A.

The American Public Health Association's recent 83rd annual meeting gave public health practitioners on international, national, state, and local levels, "new perspective which should be invaluable in future program planning," according to R. M. ATWATER, executive secretary of the association.

The meeting, held Nov. 14-18 in Kansas City along with meetings of 40 related organizations, was attended by 3,501 public health workers from public and voluntary agencies and institutions in this country and abroad. Included were physicians, dentists, nurses, engineers, nutritionists, sanitarians, veterinarians, health educators, entomologists, biologists, epidemiologists, and other specialists.

In addition to scientific meetings, those attending the sessions were brought up to date on developments in the field by 65 scientific exhibits and 82 technical exhibits in the Municipal Auditorium, where all daytime meetings were held.

"The theme of the meeting, 'Where Are We Going in Public Health?' proved to be the spark which touched off an imaginative analysis of public health practice in the light of today's human problems and tomorrow's probable needs," Dr. Atwater said. The theme was developed in two symposium sessions open to all delegates as well as in smaller meetings which probed the present status and future trends of many specialized areas of health, including city and neighborhood planning, industrial and union health programs, such regional problems as smog conditions in California, and progress in the control and elimination of various diseases.

Dr. Atwater said that the discussions pointed up mental health and care of the chronically ill as major problems of the future which undoubtedly will be emphasized during the association's 84th annual meeting in Atlantic City, New Jersey, Nov. 12-16, 1956.

Dr. Atwater stated that the meeting caused the greatest degree of public interest in the association's history. There was wide coverage by newspapers, magazines, television, and radio. Special interest centered in an address by former President Harry S. Truman in connection with presentation of the Albert D. Lasker Awards of the A.P.H.A. and on a symposium on practical experience with the Salk polio vaccine, with participation by many of the key figures in the development and utilization of the vaccine, including Dr. Jonas E. Salk and Dr. Leonard A. Scheele, Surgeon General of the U. S. Public Health Service.

The association cited the following for the excellence of scientific exhibits: The Missouri Division of Health, the Division of Intern. Health of the U.S.P.H.S. together with the Public Health Division of the Intern. Cooperation Admin., the Equitable Life Assurance Society of the United States, the Metropolitan Life Insurance Co., the Canadian Dept. of National Health and Welfare, the American Dietetic Assoc., the National Sanitation Foundation, the Pan American Sanitary Bureau, World Health Organization, and the Health Insurance Plan of Greater New York. In addition, special recognition was given to a health careers exhibit sponsored jointly by the National Health Council and the Equitable Life Assurance Society of the United States.

IRA V. HISCOCK, chairman of public health at Yale Univ., assumed the association's presidency at the end of the meeting. The new president-elect is John W. Knutson, chief of dental services of the U.S.P.H.S. and the first dentist to be elected to the position in the association's history.

Milk Industry Foundation Outlines Its Plan for Promoting Sale of Milk

C. RAYMOND BROCK, president of the Milk Industry Foundation, has outlined the following program for achieving a goal of 100% consumption of milk produced.

"We shall expand our cooperation with the Special School Milk program while developing our own efforts of parallel purpose.

"We shall encourage, through the advertising contests and the merchandising materials and plans made available through the Milk Industry Foundation, the expansion of advertising and merchandising efforts of our individual milk dealers.

"We shall diligently seek out and investigate new channels of milk distribution that will make milk more available to consumers at minimum cost. Along these lines, we shall promote the increased use of dispensing machinery in restaurants, hotels, institutions, and public places, and also the wider use of vending machines in appropriate locations, where volume justifies them.

"We shall cooperate in research activities looking toward the development of new milk products that will create greater consumer demand. Currently, research is under way on fruit-flavored milk. Strawberry-flavored milk already is on the market.

"We shall work closely with the dairy farmers, our associates in this great enterprise, to assist them, when they desire it, in developing ways of reducing their production, storage, and transportation costs.

"We shall intensify our efforts to reduce our processing and distributing costs, in the interest of maintaining the lowest possible price to the consumer. In the dairy plant, we look forward to ever-increasing mechanization. I believe the day is not too far distant when we can expect to have the milk processing plant completely 'automated.'

"Through such efforts as these, we are hopeful of achieving five major objectives. These are:

1. Greater consumption of fluid milk.
2. Lower *real* prices to consumers. (Thirty years ago an hour's take-home pay of an average working man bought 3½ qt. of milk. Today, it buys 7 qt. I predict that the real cost of a quart of milk will continue to go down in this fashion.)
3. More cash income for dairy farmers (because the farmer receives a higher price for that part of his milk production which is consumed in fluid form).
4. Reduced government expenditures of taxpayers' money for the purchase and storage of surplus milk products.
5. A more stable economy for the dairy industry, contributing to a sounder national economy.

"This is our program. I submit that it correlates our own business interests with the greater interests of the nation. We shall pursue these goals with unstinting effort. And, in their pursuit, we shall serve not only ourselves, but all milk producers, all milk consumers, and the public at large."

Ralston-Purina Company Announces Research Fellowship Awards

School Year July 1, 1956—June 30, 1957

I. Objective: to assist in the training of additional personnel for furthering the interests of agriculture, particularly the livestock and poultry industries.

II. Awards will be made in the fields of (1) nutrition and physiology research as applied to dairy, poultry, and animal husbandry; and (2) research in transmissible diseases of livestock and poultry.

III. Any individual qualified for graduate study in any Land-Grant agricultural college or approved veterinary college (including Canadian colleges) who possesses desirable personal qualifications and submits a completed application may be eligible. The application and necessary requested information must be in the hands of the Awards Committee by March 1 of the year the award is to be made.

IV. Research fellowships will be awarded on an annual basis. The recipient of an award may be eligible for appointment not to exceed a tenure of 3 years.

V. Not more than ten research fellowships shall be awarded annually, as follows: not more than three each in dairy husbandry, animal husbandry, and poultry husbandry; and not more than one in the field of veterinary science.

VI. The selection of the recipients of the annual research fellowship awards, as well as the rules governing the awards, shall be made by a committee of an officially appointed representative of each of the following organizations: Poultry Science Assoc., American Veterinary Medical Assoc., American Dairy Science Assoc., American Society of Animal Production, Assoc. of Land-Grant Colleges, and the Ralston-Purina Company.

VII. Amount of Fellowship—$1,560.00 annually.

VIII. Application blanks for these Fellowship awards may be obtained by writing the Ralston-Purina Research Awards Committee, c/o J. D. Sykes, Ralston-Purina Co., St. Louis 2, Missouri.

Long Island School to Open Night Course in Ice Cream Manufacture

The Long Island Agricultural and Technical Institute will offer this year for the fifth time an evening class in Ice Cream Manufacturing. This course will be taught on Monday evenings from 8:00 until 10:00 P.M. each week starting Feb. 6, 1956, for 12 consecutive weeks. The course is designed for those engaged in the selling and manufacture of ice cream mixes, sherbets, ices, or soft ice cream. Included is a study of the ingredients used in the manufacture of these products. The program will cover the following items: the testing of ice cream; calculation of mixes; restandardization of off-batches; processing mixes; manufacture of ice cream, ices and sherbets; use of stabilizers for ice cream, sherbets and ices; use of cocoa, chocolate, and other flavors. Some time will be devoted to the scoring of ice cream, use of washing compounds, and sanitation in the ice cream plant.

Wisconsin Dairy Plant Fieldmen to Meet

The Dept. of Dairy and Food Industries of the Univ. of Wisconsin will hold its annual conference for dairy plant fieldmen on Feb. 2 and 3, 1956, on the campus at Madison. In addition to talks by staff members from several departments of the University, there will be a panel discussion on "More Effective Disease Control" and one on "The Fieldman's Experience with Bulk Milk Handling." Practicing veterinarians, fieldmen, and plant operators will take part in these discussions. Awards for cowyard improvement programs will be presented by WILLIAM GROVES, president of the Wisconsin Dairy Federation.

Dunkley Receives Fulbright Award for New Zealand Studies

A Fulbright award has been granted WALTER L. DUNKLEY, associate professor of dairy industry, Univ. of California, to conduct research

at the Fats Research Laboratory of the Dept. of Scientific and Industrial Research, Wellington, N. Z. In a study of oxidative rancidity in edible fats Dunkley will concentrate on the chemical compounds responsible for off-flavors in milk fat.

During his stay in New Zealand he will have an opportunity to attend the Intern. Grasslands Congress, to be held at Massey Agricultural College in November, 1956, and to visit the New Zealand Dairy Research Institute. Dr. Dunkley and family will leave Davis Feb. 1 and expect to be gone a year.

Happenings at Ohio State

Left to right: C. T. Alexander, M. & R. Dietetic Laboratories, Columbus; Ralph M. Jewell, Jewell Ice Cream Co., Mt. Vernon, Ohio; Dean L. L. Rummell of the College of Agriculture; and I. A. Gould, chairman of the Department of Dairy Technology.

Over 120 alumni and friends of the Dept. of Dairy Technology witnessed the presentation of honors to two outstanding dairymen, R. M. JEWELL of the Jewell Ice Cream Co., Mt. Vernon, Ohio, and C. T. ALEXANDER of M & R Dietetic Laboratories, Columbus, at the Seventh Annual Homecoming Brunch on Oct. 29.

Mr. Jewell was presented the Award of Merit by DEAN L. L. RUMMELL of the College of Agriculture on behalf of the Department. Mr. Jewell's long and outstanding record of service to the dairy industry was cited as the basis for this award. He had served as president of the American Butter Institute, Ohio Dairy Products Assoc. and Ohio Butter Manufacturers Assoc., as well as a member of the Boards of Directors of the American Butter Institute, National Dairy Council, and Ohio Dairy Products Assoc. and as trustee of the Ohio Butter Mnfrs. Assoc., Ohio Ice Cream Mnfrs., and Ohio Milk Distributors Assoc. Past recipients of this award include H. F. MEYERS, Cleveland; ARTUR GOOD, Pickerington; EVERETT ANTRIM, Worthington; T. KLINE HAMILTON, Columbus; FRED CAMPBELL, Salem; and IRVING REYNOLDS, Toledo.

Mr. Alexander was presented with a Certificate of Appreciation on behalf of the Department by I. A. GOULD, chairman. "Alex's" long record of warm and continued cooperation with the Dept. of Dairy Technology and his service to Ohio's dairy industry were cited. He has been associated with the industry since 1917, having served as laboratory supervisor for the Wilde Milk Condensing Co.; then public relations representative for Libby, McNeill, and Libby; he organized the Blue Ribbon Dairy in Huntington, W. Va., and finally has served a term as president of the Ohio Milk Mnfrs. Assoc. and has been treasurer of the Ohio Dairy Products Assoc. for the past 7 years.

Thirty-six cream graders and buttermakers representing 18 buttermaking plants in Ohio participated in a cream grading clinic Nov. 1 and 2, held in cooperation with the Dept. of Dairy Technology of The Ohio State Univ.; the U. S. Department of Health, Education, and Welfare; the Ohio Division of Foods and Dairies; and the Ohio Dairy Products Assoc.

The purpose of the clinic was to clarify the cream grading practices of those in regulating agencies and of commercial operators as to the proper evaluation of samples of sour cream intended for churning. Cream samples, typical of those found in the field, were scored by both the company representatives and CLOYD RUSSELL, representative of the U. S. Dept. of Health, Education, and Welfare; ORRVILLE HUNNICUTT and SAM AHLMAN of the Ohio Division of Foods and Dairies; and FRANK KOVAL and W. L. SLATTER of the Dept. of Dairy Technology.

J. L. BURNS of Beatrice Foods Co., Columbus, who is president of Ohio Dairy Products Assoc., and FRED GREINER, Executive Secretary, have announced that the annual convention will be held in Columbus, Jan. 23-25. Programs are being carefully prepared to bring the most pertinent news to the members of the association.

The Education Subcommittee of the Dairy Industry Committee met in Columbus on Nov. 17 to discuss plans for an industry wide campaign for recruiting high school students for the dairy industry. J. H. ERB, The Borden Co., Columbus, presided over the meeting, which was attended by J. L. HILEMAN, representing the Dry Milk Institute; R. M. JEWELL, the American Butter Institute; ROBERT CLEARY, the Milk Industry Foundation; JOHN BARNHART and PETER OLSON, the Dairy Industry Supply Assoc.; PHIL HAYMES, the Evaporated Milk Assoc.; DON WILLIAMS, the Intern. Assoc. of Ice Cream Mnfrs.; and I. A. GOULD, representing the American Dairy Science Assoc.

Plans were studied for producing a film which might be shown to prospective students to interest them in entering the field. Also serving as a basis for discussion was the report by H. B. HENDERSON of Georgia, sponsored by the Milk Industry Foundation, concerning the many aspects of career opportunities in the dairy industry as revealed by answers given by recent graduates of dairy products technology curricula encompassing the entire country.

Dairy Institute to Study Methods and Techniques

Dairy fieldmen, sanitarians, inspectors, health officers, salesmen, educators, and executives will have opportunity to learn the latest in dairy production, health, and marketing programs, as well as the most effective ways of carrying them out, in a 2-day Dairy Institute at the Univ. of Tennessee, Feb. 20-21, 1956. Two of the nationally known speakers who will appear on the program are A. C. DAHLBERG, Cornell Univ., and C. F. HUFFMAN, Michigan State Univ.

The Institute will present not only the technical aspects of various dairy problems but also methods and techniques for getting the most effective results in the various programs. Visual aids, personal contacts, meetings, and unified program approaches to dairy problems will be discussed.

Kentucky News Items

An open house was held Dec. 15 by the Kentucky Dairy Products Assoc., Milk-for-Health, and Central Dairy Council to introduce friends of these organizations to their new quarters at 1110 S. Third, Louisville, Ky.

The Kentucky Dairy Products Assoc. is under the direction of FRANK MANNING, the Milk-for-Health program is under DAN CONLEY, and MISS EMILY BENNETT heads the Central Dairy Council.

The Tri-City Dairy Technology Society combined a Christmas party and election of officers at their last meeting of 1955 at Louisville. The new officers are: K. E. MENNEN, Armour Creamery Co., president; DON JONES, Cherry-Burrell Corp., vice-president; BURLEY KASTER, Carl Kaster Co., secretary; DON SCHRIVER, Dean Milk Co., recording secretary; CHESTER YATES, Mellwood Dairy, treasurer; and BENNY COLLINS, Plainview Farms Dairy, sergeant-at-arms. ED THOM, Olson Publishing Co., the guest speaker, discussed, "New Products and Processes in the Dairy Industry."

More than 80 members of the dairy industry attended the Third Annual Kentucky Dairy Manufacturing Short Course, Nov. 28-30. The program, sponsored jointly by the Univ. of Kentucky Dairy Section and Dairy Products Assoc. of Kentucky, for the first time included a program for cheese manufacturers. Guest speakers on the program were: DEAN MURPHY, Armour Creameries; H. E. WALTER, Dairy Manufacturing Technologist of the U. S. Dept. of Agriculture; and H. L. WILSON, Kraft Foods Co.

Much interest was shown in both the market milk and ice cream programs. Most of the market milk session was devoted to problems of cultured milk and cottage cheese under the leadership of N. C. ANGEVINE, Meyer-Blanke Co. R. L. CONNOR, Falls City Milk Producers Assoc., discussed the problems facing the fieldman.

D. H. WILLIAMS, Intern. Assoc. of Ice Cream Manufacturers; I. O. HITT, National Dairy Products Corp.; and D. V. JOSEPHSON, Pennsylvania State Univ., were guest speakers on the ice cream program. Those attending the session showed much interest in the ice cream exhibit and were particularly interested in the impromptu remarks of Dr. Josephson concerning the techniques of judging. Samples of buttermilk, cottage cheese, and Cheddar cheese were submitted by various dairies in the state. Mr. Angevine graded and commented on the buttermilk and cottage cheese. The Cheddar cheese grading was done by Mr. Wilson.

Each morning the sessions recessed for milk furnished by the American Dairy Assoc. On the second day J. O. BARKMAN supervised a coffee and doughnut "eye-opener" before the session started. A supper and smoker was sponsored by the Univ. of Kentucky Dairy Club at the end of the first session. Members of the Tri-City Dairy Technology Society joined the short course for the annual banquet. Dr. Josephson discussed "Contributions of Science to Our Industry."

Abstracts of most of the talks presented at the short course were given those attending. Copies of these abstracts may be obtained, while the limited supply lasts, by writing DR. T. R. FREEMAN, Dairy Section, Univ. of Kentucky, Lexington.

Members of the planning committee for the short course appointed by D. M. SEATH, head of the Dairy Section were: T. R. FREEMAN, chairman; J. O. BARKMAN, M. W. DUNNING, JR., W. L. KING, W. F. LEWALLEN, A. W. RUDNICK, JR., all on the dairy staff. DR. FRANK J. WELCH, dean and director of the College of Agriculture, welcomed the short course group.

Illinois Holds Training Schools for Bulk Milk Tank Haulers

To better acquaint drivers of bulk milk tank trucks with the problems related to bulk milk handling, the Univ. of Illinois Dept. of Food Technology, the Illinois Dept. of Public Health, and the Division of Foods and Dairies of the State Dept. of Agriculture are cooperating in conducting a series of one-day training schools. Registration is limited to 80 for each school. Those attending are divided into groups of 20 each to permit maximum discussion of the subject matter presented. The program is supervised by P. H. TRACY of the Univ. of Illinois. The first two schools were held at Rockford in December. The third was held at Springfield, January 25.

Diversey Expands into South America

The Diversey Corp. of Chicago has become the first manufacturer of sanitation products

in Venezuela. A new subsidiary, Industrias Consolidadas of Caracas, Venezuela, has been formed, according to W. E. NOYES, vice-president in charge of sales for Diversey. "The Venezuelan economy is expanding rapidly, particularly in the food manufacturing field," said Noyes. "We are already working closely with food manufacturers there to bring sanitation practices up to date with recent developments here in the United States." Mr. Noyes was named president of Industrias Consolidadas by H. W. KOCHS, chairman of the Board of The Diversey Corp. C. W. BRADLEY of Caracas, Venezuela, is vice-president of the new firm and JORDAN YOUNG is general manager.

The plant being established in Caracas will manufacture a complete line of supplies, including bactericides and specialized cleaners for all types of food manufacturing equipment and processes. The new South American subsidiary is the most recent of Diversey's expansion moves into foreign markets. Manufacturing plants are now operating in Sydney, Australia; Honolulu, Hawaii; Toronto, Canada; and St. Johns, Newfoundland. In the United States, Diversey has plants in Chicago; Los Angeles; Newark, N. J.; and Chippewa Falls, Wis.

West Virginia Offers New Course

A group of 4-week courses known as the "Farm and Home School" is being offered for the first time by the College of Agriculture, West Virginia Univ. Scheduled for Feb. 6–March 2 are "The Feeding and Management of Dairy Cattle" and "Farm and Home Planning." The Division of Home Economics is also offering two courses designed as practical beyond the high school level to enable the students to do better jobs on their home farms. Each course will include a large amount of laboratory work.

J. E. FIKE, for the past 8 years a member of the Dairy Staff, has accepted a position with Southern Dairies, Norfolk Division.

More than 30 dairy plant men attended a recent 2-day Buttermilk, Cottage Cheese, and Culture Clinic under the direction of S. J. WEESE. The Dept. of Bacteriology and several industry men cooperated in conducting the clinic.

Montana Holds Dairy Industry Meeting

The Montana State College held its annual Dairy Industry Week Nov. 14-16 in cooperation with the Montana Purebred Dairy Cattle Assoc. J. A. NELSON was chairman of the planning committee. Visiting speakers included J. C. BOYD of the Univ. of Idaho, E. L. THOMAS of the Univ. of Minnesota, M. N. WARNICK, president of A.D.A., and B. R. WEINSTEIN of Crest Food Co., Ashton, Ill.

Utah Holds 2-Day Meet

The Utah State Agricultural College Extension Service in cooperation with the Utah Dairy Industry held their annual dairy conference Nov. 9 and 10. Featured speakers were R. E. ERB of Washington State College and M. N. WARNICK, president of A.D.A. L. H. RICH was chairman of the program committee.

Bowman Dairy Expands

The Bowman Dairy of Chicago, an 80-year-old organization has added to its list of recently acquired dairy plants the Richer Dairy Products Co. of Columbus, Ohio, and the Iowana Farms Milk Co. of Bettendorf, Iowa. The Bowman Co. has been expanding its markets outside of Chicago for several years. F. H. KULLMAN, JR. is president of the company.

Thomas Returns from Colombia Fair

E. L. THOMAS has recently returned from Bogota, Colombia, where he assisted with an educational Dairy Products Exhibit held in conjunction with an Intern. Trade Fair. The Fair was sponsored by the Colombian government.

Mercury-Switch Fencer Flashes 300 Million Times

Almost 6 years ago, an electric fencer was plugged into a 110-volt outlet at Belvidere, Ill., to check the length of life of a tumbler-type mercury switch. Today that unit still runs continuously, making and breaking contact about 86,000 times a day. The manufacturers, Babson Bros. Co of Chicago, estimate this unit has flashed about 300 million times since it was plugged in. There's no sign of wear, and the 25-milliamp spark is as strong as ever.

The old problem of electric fencers—contact points that stick—apparently has been solved by the globule of mercury that tumbles back and forth across the points. This type of fencing has simplified servicing and has reduced maintenance costs for the dairy farmer.

Completed Theses

M.S. Degree:

RAYMOND P. CIAGNE—Investigations of some chemical and bacterial properties of several dairy plant water supplies. Univ. of Minnesota.

Ph.D. Degree:

SIMPEY KURAMOTO—The application of the Tiselius-Claesson interferometric adsorption analysis apparatus to *P. roqueforti* lipase studies on butterfat. Univ. of Minnesota.

LETTERS TO THE EDITOR

Member Responsibility

Did it ever occur to you, dear Member, that when you pay your annual dues of ten dollars that you not only have a right to expect something from your Association but, also, you accept a real responsibility to contribute something to the Association? Only in this way can the Association live and can you expect the value of what you get from it to increase. I have received a few letters from members recently which would indicate that they are not sufficiently familiar with the affairs of the Association, including the "Journal of Dairy Science." Perhaps the membership has not been kept sufficiently well informed and then again, perhaps the Journal has not been looked over from cover to cover and the information pertaining to the Association fully absorbed.

Every member who gives the matter any thought must realize that there is room for an increase in the Association activities and a definite room for improvement in our present activities. I am sure that no member wants to see the Association step backward after 50 years of growth and service. Right now, when we are in the midst of a membership campaign, the thing that should be of interest to every member is MONEY. Do you realize that it costs between $140 and $150 a day or $1,000 a week—about $52,000 a year—to operate the affairs of the Association? Eighty per cent of this cost goes into the Journal. This year we shall do well if we make both ends meet. We are getting some more advertising and that will help, but what is desperately needed for a healthy growth of the Association is more members and more subscribers.

The great majority of those engaged in teaching, research, and extension work are already members; therefore, our new members and subscribers must come mainly from those engaged in industry and various other agricultural pursuits. The Association cannot exist and publish its Journal without members and help from these sources.

A tabulation of the returns to date indicates that fully a third of members are from the processing industry and about 10% from the equipment, manufacturing, and supply field. I have been interested to find that not more than two or three county agents are listed as members in over 1,000 memberships received to date. There must be hundreds of strong dairy counties throughout the United States and certainly their county agents should be members.

Libraries of all kinds are the larger source of subscriptions. There should be many more subscriptions from processing firms and dairy equipment and supply firms. Do you realize that we have more subscriptions by nearly 200 in foreign countries than we have here in the United States? And did you know that Japan with 81 subscriptions leads all the foreign countries and has more subscriptions than New York State with 68, which is the top state in this country? Maybe it is the old story of a prophet not being appreciated in his own country!

Now then, the slogan "Every member get a member" is not new, but I think you can see from what I have said that if in your various communities you will try to get a member or subscription, you will be doing the Association and yourself, because it is you, yourself, who *are* the Association, a real service. I can assure you that you won't have much luck by writing letters to prospects, but if you will bestir yourself to actually talk to a prospect, either as a member or a subscriber, I guarantee you will land him in far better than 50% of the cases. Some of the prospects, particularly in the processing field, may complain that the Journal does not feature a sufficient number of articles in this field. That criticism has been made. The soundest argument in the world to combat such a statement is that maybe only one good article or a few good articles, if they contain information that the reader needs, will be worth all the membership or subscription costs and often very much more. For example, the article entitled "The Miracle of Milk" appearing in the September, 1955, issue is certainly a masterpiece. "A Guide for Secondary School Recruitment Programs in the Dairy Industry" in the same issue certainly should be of much interest to industry. On the production side "A New Concept of Parity" appearing in the August issue is worthy of note. Professor Thomsen's article on "Efficiency in the Operation of Dairy Plants" in the July issue is of interest to industry, and I am told that the article in the November issue "How to Control Shrinkage in Ice Cream" is very good indeed.

So, what do you say, fellows? Let's wake up and live! See how many memberships or subscriptions you can send me in the next few weeks. We are having enough January Journals printed to take care of them.

H. F. JUDKINS
Secretary-Treasurer

Dr. Wilster Writes of His Experiences in Denmark

It was early morning August 11, 1955, when the M/S Oslofjord entered Øresund. What a thrill it was for me to see the majestic sunbathed Kronborg castle with its green copper towers. It was just such a sight I had longed to see on my return to the country of my birth after an absence of 44 years. It was my wife's first glimpse of Denmark, where her parents were born. On the way down the Sound we could see the red-roofed houses and green forests. Soon the tall green towers of Copenhagen were visible. I was returning home to spend nearly one year in Denmark under the Fulbright program.

As the ship neared the pier we could see hundreds of people waving, many with Danish or American flags in their hands; others held huge "welcome home" signs. Then as the ship tied up, there was silence while "Kong Christian Stod Ved Højen Mast," "Du Gamla, Du Fria, Du Fjällhöga Nord," and "The Star-Spangled Banner," were played over the amplifiers. It was very impressive. What a homecoming!

Then there was a pleasant surprise. On the pier was displayed a large sign with the words "Fulbright." And soon we heard the pleasant words, "Welcome to Denmark," from Mrs. Karin Fennow and her associate, Mrs. Jeanne Steinmetz. Soon we were in a taxi on the way to Hotel Hafnia, where we enjoyed the first of many delicious Danish meals.

It is very difficult to describe how one feels when he returns to his home country after having been in New Zealand, Australia, and the United States for so many years. Although Denmark is about 6,000 miles from Oregon, I do not feel that I am in a foreign country. Both my wife and I feel quite at home and we are very happy to live in Denmark. We are impressed with the tidiness of the towns and with the country. The people are well dressed. Courtesy is the rule. One says "Vaer saagod" when he hands something to another person and no one forgets to say "Tak" or "Mange Tak" when he receives something. It is "hyggeligt" here in Denmark.

We had an opportunity to travel during August from the north to the south of Denmark. We enjoyed warm, sunny days. We visited farms, creameries, and churches, and saw memorials from the stone age. The country was beautiful. When traveling by train or bus we never tire of looking at the verdant fields with the contentedly grazing red cows, the grain fields, and the picturesque neatly kept farm buildings.

It was a great experience to attend a dairy exhibition at Herning in central Jutland. A total of 808 tubs of golden butter and 457 cheeses of different kinds were exhibited in a huge hall, and a corps of white-clad young women assisted in giving samples of the tasty products to the thousands of visitors. The products were made only in Jutland dairy plants. What a great experience it was for my wife and me to attend this great show! There is nothing in the United States to compare with it.

Denmark is a great food producer. The Danish prosperity depends to a large extent upon the sale of agricultural products abroad, particularly in Great Britain. Of all Danish exports, agricultural products account for two-thirds. Their value in 1954 was almost 4 billion kroner. Butter and cheese had a value of 1⅕ billion kroner.

During a recent week-end we spent a day at Aarhus, where we greatly enjoyed seeing "The Old Town," which consists of a number of old houses that have been moved from various Danish towns. Some of the houses contain historical collections from urban homes; others are workshops as they appeared a century ago. An old apothecary shop was especially interesting. The buildings are charmingly located in a garden with small lakes. The whole place is "fortryllende" (enchanting).

We also spent a day in the town of Ebeltoft in the section known as Mols. This is a very picturesque area and the town with its several-hundred-years-old houses and its quaint town hall is like a picture from Hans Christian Andersen's story book. All Fulbrighters ought to visit this town and should purchase the tales about the wise old Molbos. I went down in the dungeon in the little town hall. It was damp and dark, and I can imagine that a prisoner would have felt very uncomfortable sitting there on the cold floor with a chain around his leg.

I am looking forward to spending many pleasant hours during week-ends the coming winter in the interesting places in Copenhagen, such as The National Museum, Thorvaldsen's Museum, The National Art Gallery, The Glyptotek, The Royal Library, Rosenborg Castle, and others.

Of course, my main purpose during my stay in Denmark is to contribute something in the field of dairy industry under the Fulbright program; this I shall endeavor to do, but while here my wife and I shall enjoy studying Danish history and culture. It will be a rich experience for us.

G. H. WILSTER
Sept. 16, 1955

STUDENT CHAPTER NEWS

A section devoted to the activities of dairy students

E. L. THOMAS, *Editor*

Iowa State College Dairy Club Activities

The Dairy Club of Iowa State College finances field trips and other projects through income received from the sale of ice cream, cheese, milk, and milk drinks during Veishea Days, held at the campus each spring. Veishea is considered to be the world's largest student-organized function. The only other source of income for the club is a lifetime membership fee of one dollar. The development of leadership ability is stressed more than fund raising, and sales are actually a small portion of the club's work during Veishea Days.

Kentucky Students Sponsor Faculty-Alumni Breakfast

Alumni and friends of the Dairy Section of the Univ. of Kentucky assembled for breakfast on Nov. 19. The annual event was sponsored by the University's Dairy Club.

R. J. RYAN, dairy manufacturing senior and president of the club, acted as toastmaster. D. M. SEATH, head of the dairy section, introduced the dairy staff, and each member of the staff in turn introduced guests attending the breakfast.

After a review of the records of both the dairy cattle and dairy manufacturing judging team, the Dairy Club presented members of these teams with belt buckles.

After adjournment, most of those attending the breakfast attended the football game and felt their day was complete when University of Kentucky beat their arch rival, Univ. of Tennessee.

Louisiana Dairy Science Club Organizes Lecture Series

The L.S.U. Dairy Science Club has initiated a series of talks by guest speakers on the opportunities in dairying. On the program so far have been BOB CAIN, a fieldman from the Holstein-Friesian Assoc., and two Louisiana men, GEORGE WHITE and LOUIS ROBINSON, prominent in the field of dairy manufacturing. These meetings are open to the public.

Minnesota Club Sponsors Faculty-Student Smoker and Milk Hour

The Minnesota Dairy Science Club welcomed over 20 new members at its first meeting on Oct. 11. The club is looking forward to a good year that will be filled with numerous events throughout each quarter.

The Annual Student-Faculty Smoker was held Nov. 8. At this meeting dairy students and faculty members are provided the opportunity to become better acquainted. This event is a high light of the Fall quarter activities. J. B. FITCH, head of the Dairy Department, was the guest speaker.

On Nov. 29, the Dairy Science Club and the Home Economics Society cosponsored a highly successful milk hour in the St. Paul Campus Student Union. This is a quarterly activity of the club. Free milk was served, along with quantities of cheese, crackers, and donuts. A musical program was presented by members of the Home Economics Society.

O.S.U. News

On Oct. 8, the Dairy Technology students of the Ohio State Univ. entertained their summer employers at the annual Student-Employer Day. A short program expressing appreciation for summer employment was followed by a lunch served by members of the Dairy Club. Then the group moved to the football stadium to witness the Ohio State–Illinois football game.

An informal Student-Faculty "Bean Feed" was held on Oct. 20. After a rough and tumble touch football game between the new and the old students, dinner was served. After a hearty meal, an informal meeting was held in which students discussed the programs of the several clubs open to dairy technology students. I. A. GOULD, Dairy Technology Dept. chairman, closed the meeting with a short talk directed to freshmen.

Rutgers Dairy Department News

The Dairy Science Club was awarded first place for its exhibit at the Annual Barn Hop. There were five exhibits set up by the various agricultural clubs on campus. This was the second consecutive year that the Dairy Club won the prize.

The Dairy Department sponsored a dairy products judging team in the recent Collegiate Students Intern. Dairy Products Judging Contest held in St. Louis. This was the first time in several years that such a team has been organized.

A relatively new curriculum in Dairy Administration is finding favor among the students. Rutgers was a pioneer in establishing this type of curriculum. The curriculum prepares the students for administrative, as well as technical, positions. The courses of study are equally divided among dairy industry, business administration, liberal arts, and the basic sciences. This provides a well-rounded education.

Texas Tech. Dairy Industry Club Activities

The 20th Annual Homecoming Breakfast for alumni and guests of the Dept. of Dairy Industry was held Nov. 5. The breakfast was prepared and served by Club members to seventy guests.

During September, 1955, the Dairy Products Institute of Texas initiated a scholarship program for outstanding high school students to study dairy industry at Texas Tech. The value of this scholarship is $250 each year for 4 years. KENNETH KERRICK of Fabens, Texas, the first winner, is now enrolled at Texas Tech.

Virginia News

W. S. GRIFFITH has joined the staff of the Dept. of Dairy Science. He assumed his duties as assistant professor of dairy science and dairy specialist on Nov. 1, 1955. Griffith received his B.S. from Penn State Univ., and his M.S. degree from L.S.U.

W. B. ALLISON, JR., a senior in the Dept. of Dairy Science, received the $500 Ralston-Purina scholarship. Mr. Allison is chairman of the 1956 Agricultural Exposition, business manager of the Tech-Nique and president of the Virginia Tech. chapter of the A.D.S.A. ALLEN RAKES received the 1955 Borden Scholarship Award of the School of Agriculture. He is a senior in the Dept. of Dairy Science.

OUR INDUSTRY TODAY

Brief Reviews of Current Topics

Glamorous vs. Profitable Feeding of Dairy Cows[1]

C. R. Hoglund

Michigan State University, East Lansing

The glamor of high milk production records regardless of cost no longer has the appeal it once enjoyed, for bossy has become a bread and butter girl on the more efficient dairy farms. Even the more progressive purebred breeder is finding it desirable to feed for more profitable milk production rather than for high records. Lower prices for milk accompanied by continued high prices for feed, labor, equipment, and other production items, mean increased emphasis on feeding efficiency. The prestige of dairymen no longer depends on high milk production records. The more successful and respected dairymen today are those who can obtain more profits from their dairy operations.

Knowledge of Principle of Diminishing Returns Is Important

From an economic standpoint, there is no one most profitable level of feeding for all times. The optimum quantity of grain (concentrates) and roughage to feed is not fixed. Rather, it is determined by such important factors as *(a)* the production response of cows differing in inherent productivity, *(b)* the quality of roughage fed, and *(c)* the price relationships between feed and milk.

A knowledge of the principle of diminishing returns becomes important in determining the optimum combination and quantity of grain and roughage to feed. Diminishing return to a variable factor of production exists when each additional unit of an input adds less to total production than the previous unit. In dairy cows, the output of milk increases at a decreasing rate when additional quantities of grain are fed. As more grain is fed, cows eat less roughage, but total consumption of feed, when measured as TDN, increases with each additional input of grain. Total feed costs also increase as more grain is fed.

The concept of diminishing returns implies a fundamental condition for the optimum or most profitable dairy feeding system. Briefly, it states that additional units of feed are to be added until the last input just pays for itself in the increased value of the extra milk produced.

It is not uncommon for a dairyman to refer to an individual cow as a "10,000-lb. producer." Actually, the possible production from such a cow might range from 7,500 to 11,000 lb. milk annually, depending on the quantities of feed consumed (Figure 1). However, the economic range is much narrower than this.

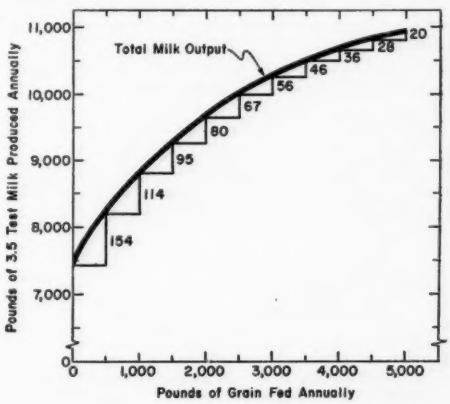

FIG. 1. Milk production response to different levels of grain feeding, good Holstein cows having basic productivity of 10,000 lb. of milk when fed grain at rate of 1 lb. to 4 lb. of milk produced and medium quality roughage. As grain is fed at heavier rates, the additional quantities of milk produced become less and less.

Input-output data have been developed for good Holstein cows (basic producing capacity of 10,000 lb. of 3.5% test milk when fed grain at the rate of 1 lb. to 4 lb. of milk produced) fed variable quantities of grain and all the medium quality hay and pasture they would consume. When the ration consists entirely of roughage, production of milk is estimated at about 7,500 lb. The first 500-lb. input of grain adds 770 lb. of milk, or an average of 154 lb. for each 100 lb. of grain fed. As additional units of grain are fed, the extra milk produced

[1] Journal Article 1747 from the Michigan Agricultural Experiment Station.

becomes less and less until the tenth unit adds only 20 lb. of milk for each additional 100 lb. of grain (Figure 1).

It becomes obvious that the optimum level of grain feeding depends on the price of milk and the cost of producing this additional milk (cost of the extra grain minus the value of the roughage saved). It would seldom be profitable to feed as much as 5,000 lb. of grain to cows that produce only 20 lb. of milk for each additional 100 lb. of grain fed at this level. On the other hand, it usually pays to feed some grain, even under the least favorable price relationships.

Cow's Inheritance Sets Economic Limits on Level of Grain Feeding

A cow's inherent capability to convert feed efficiently into milk sets the economic limits of grain feeding. An old adage states that "you cannot make a velvet purse of a sow's ear." Neither can a dairyman transform a low producer into a good producer merely by feeding grain at heavy rates. However, the quantity of milk produced by a cow annually is greatly influenced by the quantity of grain fed.

Dairymen who buy cows or herd sires from dams with high production records are often disappointed in the results on their own farms. Performance records do not tell the conditions under which these records were obtained. A casual look at the D.H.I.A. production records for two Michigan farms, designated as A and B, shows an annual milk production per cow of about 14,200 lb. for both herds. Is this a true indicator of their producing capacity? An examination of the feed records on farm A shows that this 14,200 lb. record resulted from the feeding of about 2,700 lb. of grain mixture, and on farm B with 6,500 lb. of grain mixture (Figure 2).

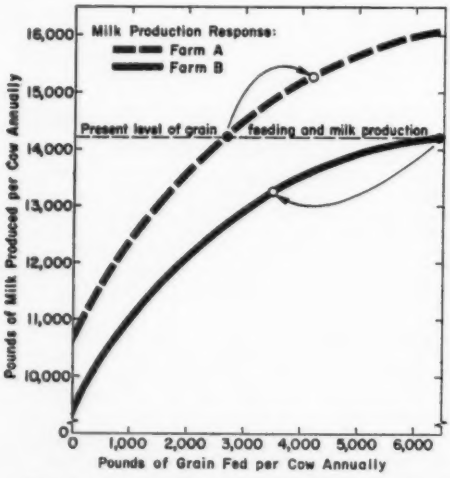

FIG. 2. Estimated milk production response to different levels of grain feeding for two herds of Holstein cows differing in inherent milk-producing capabilities. Arrows point out needed adjustments in levels of grain feeding and milk production.

When the production response of cows of different capabilities is known, it is possible to determine the most profitable rates of grain feeding. Using present milk-feed price ratios, the optimum level of grain feeding for the cows on farm A would be at approximately the 4,200 lb. rate. Milk production at this grain feeding level would be about 15,250 lb., or about 1,050 lb. more than that actually produced when grain was fed at the lighter rate. This adjustment in grain feeding would result in an approximate $40 increase in gross income per cow (1,050 lb. of milk at $3.80 per cwt., the assumed farm price of milk). Deducting the additional feed expense of $32 (1,500 lb. grain at $2.80 per cwt. less value of hay saved —0.5 T. at $20) leaves a net gain of $8 per cow.

On farm B, the rate of grain feeding would be reduced to about the 3,500 lb. level and the output of milk to 13,250 lb., or about 950 lb. less than that actually produced when grain was fed at the heavier rate. This adjustment in grain feeding would result in a $36 reduction in gross income per cow (950 lb. of milk at $3.80 per cwt., farm price of milk). This loss in income would be offset by a $72 saving in feed (3,000 lb. grain at $2.80 per cwt. less value of additional hay fed—0.6 T. at $20). The net result would be a $36 gain in returns above feed cost per cow. When grain feeding rates are adjusted to the levels at which the cost of the last input of feed just equals the value of the additional milk produced, it becomes evident that the cows in herd A have a 2,000 lb. greater producing ability than those on farm B.

Adjust Glamorous Records to Farm Conditions

The desire to excel is a normal human trait. Sometimes this desire to achieve outstanding records is both costly and misleading. An outstanding milk production record may be obtained on an individual cow well above her usual performance and her inherent capability. A 21,530 lb. record made by a mature Holstein cow is a good example. This cow produced this record when milked three times daily during a 330-day lactation period. She carried a calf for only 95 days of this period. Grain was fed at an average rate of 1 lb. to every 2.5 lb. of milk produced.

What is the real productive capacity of this cow? Experimental data indicate that three-times-a-day milking adds about 15% more milk than realized by twice-a-day milking. A study by R. E. Erb and associates of the Dairy Department of the Washington Agricultural Experiment Station showed that cows with the

same inherent capabilities produced about 10% more milk when they carried a calf 100 or less days compared with 200 or more days of the lactation period. When adjustments are made for the three-times daily milking and the long freshening interval, the milk production figure for the above cow is brought down to 16,200 lb.

A further adjustment of 8% for the heavy grain feeding reduces the milk production figure to about 15,000 lb., or 6,500 lb. below what her record showed. This is the cow's inherent capability, on a mature basis, to produce milk when milked twice daily, with a 12-month freshening interval, and when fed grain at the ratio of 1 lb. to 4 lb. of milk produced.

Adjust Feeding Rates to Quality of Roughage

The quality of roughage fed also affects the optimum combination and level of grain and roughage to feed. The higher the quality of roughage, the less is the response in milk produced when increased quantities of grain are fed. It is estimated that when good cows are provided all the excellent roughage they will consume and no grain, they will attain about 85% of their basic producing capacity. This compares with 75% when medium quality roughage is fed and 64% when poor quality roughage is fed (Figure 3).

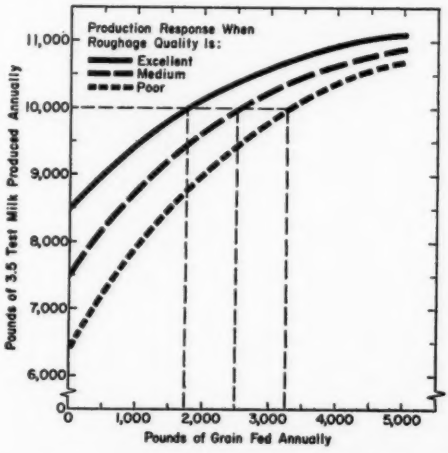

FIG. 3. Milk production response to different levels of grain feeding when excellent, medium, and poor quality roughage is fed to good cows.

To produce 10,000 lb. of milk from these good cows will require only about 1,700 lb. of grain when excellent quality grass silage, hay, and pasture are provided. This grain feeding rate increases to 2,500 lb. with medium quality roughage and to 3,250 lb. with poor quality in producing 10,000 lb. of milk (Figure 3). The protein supplement portion of the grain mixture can be reduced as roughage quality is improved. A saving in the amount of both grain and protein fed can reduce feed costs by as much as $20 to $30 per cow.

Milk-Feed Price Changes Call for Feeding Adjustments

Dairy farmers are faced with the problem of adjusting their feeding practices to milk-feed price changes if maximum net returns are to be obtained. It is important that dairymen know the production response of cows having different inherent capabilities when fed roughage of different qualities. Dairy scientists in cooperation with production economists need to develop more fully these basic research data. The problem then becomes one of the dairy farmer first determining the production capacity of his individual cows (through D.H.I.A., owner-sampling or weighing milk himself) and then applying current prices to milk and feed in order to find the most profitable feeding rate.

A simple but incomplete method of determining the most profitable rate at which to feed grain is to calculate the milk-grain price ratio and equate this with the incremental increase in milk production (marginal productivity of grain). The price of 3.5% test milk in southern Michigan in early 1955 averaged about $3.80 per cwt. The cost of 100 lb. of grain mixture averaged about $2.80 per cwt. The milk-grain price ratio would thus be 0.73 ($2.80 ÷ $3.80 = 0.73). An examination of Figure 1 shows that 73 lb. of additional milk would be produced for each additional 100 lb. of grain fed somewhere between the 2,000 and 2,500 lb. grain level.

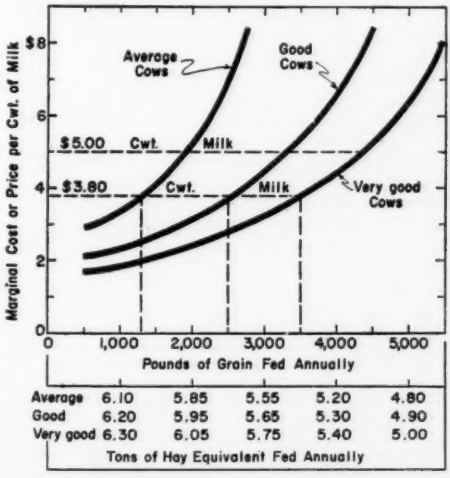

FIG. 4. Marginal cost in producing 100 lb. milk, medium quality roughage, three qualities of Holstein cows. Prices used were: grain, $2.80 cwt.; hay, $20 T.; pasture, $22.50 acre.

This method underestimates the most profitable rate at which to feed grain by about 250 lb. because it does not take into account the value of roughage saved when more grain is fed. Increasing the rate of grain feeding from 2,250 to 2,500 lb. would reduce hay intake by about 140 lb. per cow. Milk production would be increased by about 200 lb. for good cows. When hay is priced at $20 per ton, grain at $2.80 per cwt., and milk at $3.80 per cwt., feeding the extra 250 lb. of grain would add about $2 to net returns per cow. (Value of additional milk minus cost of additional grain + value of hay saved). If hay is priced at $50 per ton with no change in the prices of grain and milk, net returns would be increased by $4 per cow.

Another method of determining the optimum grain feeding level is to calculate marginal costs and then equate marginal returns with marginal costs. Marginal cost curves have been calculated for average, good, and very good Holstein cows fed medium quality hay. These cows have the inherent capabilities of producing 7,000, 10,000, and 13,000 lb. of milk, respectively, when fed grain at the rate of 1 lb. to 4 lb. of milk produced. The following prices were used: grain, $2.80 cwt.; hay, $20 T.; and pasture, $22.50 per acre.

The most profitable rates of grain feeding with milk netting $3.80 per cwt. on the farm would be at the 1,300-lb. level for average cows, 2,500-lb. level for good cows, and 3,500-lb. level for very good cows (Figure 4). If dairymen received $5.00 per cwt. for milk and the cost of grain and hay remained unchanged, then the most profitable grain feeding rates would be 1,900, 3,200, and 4,300 lb., respectively, for the three qualities of cows. If the net farm price of milk approached $3.00 per cwt., as it has for some dairymen who sell milk on a manufactured market, it would pay to feed grain only at light rates.

Biology and Social Problems

E. ROBERTS

Department of Animal Science, University of Illinois, Urbana

Human welfare is profoundly affected by population growth. The Biblical commandment, "Be fruitful and multiply," has been fully obeyed. In 1800 world population was estimated to be 919,000,000, and in 1950, 2,406,000,000 (Table 1). This increase has occurred while the world has been ravaged by disease and famine. The power of a people to recuperate from losses resulting from disease and famine is phenomenal. A little more than 600 years ago the Black Death (bubonic plague) started in Asia and spread to Europe. It has been reported that the population was reduced by one quarter to one half and that in two or three generations this enormous loss had been overcome.

An estimated population in China in 1500 was 60,000,000, and today the population is well over 400,000,000. In European countries which were directly involved in World War II the estimated increase between 1940 and 1950 was 11%.

TABLE 1

Estimated world population (10)

Date	Population
1650	470,000,000
1750	694,000,000
1800	919,000,000
1850	1,091,000,000
1900	1,571,000,000
1950	2,406,000,000
1954	2,625,914,000[a]

[a] Britannica Book of the Year. 1955.

TABLE 2

Population of the United States (10, 11)

Date	Population
1650	52,000
1700	275,000
1750	1,207,000
1800	5,308,000
1850	23,260,000
1900	76,129,000
1910	92,267,000
1920	107,190,000
1930	123,091,000
1940	131,669,000
1950	151,677,000
1954	162,414,000[a]

[a] Estimated.

Population in the United States has increased rapidly from 5,308,000 in 1800 to 151,677,000 in 1950. The estimated population in 1954 was approximately 162,414,000 (Table 2). Because the country is new and allowed almost unrestricted immigration until World War I, a rapid increase was natural. About 40 years ago predictions were made that by 1950 our population would have become static. As late as 1938 *(12)* the estimated population for 1950 was 143,898,000 and for 1955, 149,353,000. According to the United States census, the population for 1950 was 151,677,000 and the estimated population at the present time is more than 163,000,000. Our population will probably increase for a long time.

Birth Rate Increasing—Death Rate Decreasing

In Table 3 are shown birth and death rates in the United States from 1915 to 1954. The birth rate reached a low of 16.6 per 1,000 population in 1933, rose in 1934 to 17.2, and again was low in 1935-36. The rate for 1947 (25.9) was the highest on record in the United States. The death rate in 1915 was 13.2 and in 1954 reached a low of 9.6 per 1,000 population. A decreasing birth rate does not result necessarily in a static population. The increase in the population would cease when birth and death rates become the same, and in the absence of immigration. If India's present birth rate of 32 per 1,000 were maintained and her death rate of 24 per 1,000 replaced by our rate of 9.6, the increase in population in 100 years would be enough to fill five earths as large as ours with as many people in each as we have today *(1)*.

In a country with an increasing population and a decreasing per capita wealth, changes in the number and kinds of domestic animals are likely to occur. At first the number of larger animals would decrease and the numbers of smaller animals and chickens would increase. The diet of a large part of the population would contain less meat and animal products and more of plant origin. In a new country like the United States animals are an important source of food.

World's Food Supply Must Be Doubled by Year 2000

There are not more than four billion acres of arable land on the earth, according to Hugh H. Bennett, former Chief of the United States Soil Conservation Service. This is not quite two acres per capita. Some say that 2½ acres, with present methods of food production, are necessary for an adequate diet. With 2½ acres per person, with average production records, 1,600,000,000 could be fed adequately. If the food supply were doubled, 3,200,000,000 could have an adequate diet. By 2000 the estimated population will be about 3,300,000,000. It is certainly not possible for the United States to feed the world, or even provide one country like China with an adequate diet.

If the world population is to be fed adequately, there must be an enormous increase in the amount of food produced. Increase can be made by improving and extending present methods of production; through the use of now uncultivated areas; possibly through the discovery of new methods of making synthetic foods; and by making greater use of the ocean as a source of food.

Size of American Family Now on Increase

Size of family gradually decreased in the United States until recently. During the last 15 years the birth rate has shown an upward trend (Table 3). However, the number of children under 5 years of age per 1,000 women 16 to 44 years of age, decreased from 976 in 1800 to 329 in 1940 (Table 4). The effect of such decreases has been partially offset by the decrease in the death rate, especially among infants, and an increase in life expectancy.

TABLE 3

Birth and death rates, United States (per 1,000 population). (11, 13)

Year	Birth rate	Death rate	Year	Birth rate	Death rate
1915	25.0	13.2	1935	16.9	10.9
1916	24.9	13.8	1936	16.7	11.6
1917	24.5	14.0	1937	17.1	11.3
1918	24.7	18.1	1938	17.6	10.6
1919	22.4	12.9	1939	17.3	10.6
1920	23.7	13.0	1940	17.9	10.7
1921	24.2	11.5	1941	18.9	10.5
1922	22.3	11.7	1942	20.9	10.4
1923	22.1	12.1	1943	21.5	10.9
1924	22.2	11.6	1944	20.2	10.6
1925	21.3	11.7	1945	19.6	10.6
1926	20.5	12.1	1946	23.3	10.0
1927	20.5	11.3	1947	25.9	10.1
1928	19.7	12.0	1948	24.4	9.9
1929	18.8	11.9	1949	24.6	9.7
1930	18.9	11.3	1950	24.1	9.6
1931	18.0	11.1	1951	24.9	9.7
1932	17.4	10.9	1952	25.0	9.6
1933	16.6	10.7	1953	25.1	9.6
1934	17.2	11.1	1954	25.0	9.6

TABLE 4

Children under five years of age per 1,000 women 16 to 44 years of age among white population in United States (6)

Year	Number
1800	976
1840	835
1880	635
1920	486
1930	407
1940	329
1950	479

Educated People Have Fewer Children

Among certain people, fertility as measured by number of children is so low that their proportion of the population is not being maintained. As the number of years spent in school increases, the size of the family decreases (Table 5). For those with less than 7 years of schooling the number of children is 4.1, but for those with 4 years of high school or 1 to 4 years of college, the number has dropped to about 1.7.

In 1947, a study was made of the number of children of the graduates for the years 1921 and 1922 of several colleges and universities (Table 6). This was at least 25 years after

TABLE 5

Education and number of children of women 40-44 years old (1)

Education	Number of children
1-4 years of college	1.69
4 years of high school	1.71
1-3 years of high school	2.12
8 years of grade school	2.50
Less than 7 years schooling	4.11

graduation and well beyond the usual child-bearing age. For men graduates the average number of children was 1.7 and for women 1.4. Approximately 2.2 children per woman of child-bearing age are required to replace the population. Some evidence has been found that persons with higher intelligence quotients, regardless of their economic status, have the smaller families. Why are the more educated having smaller families? One reason is that their economic and biological maturities are widely separated, reducing the child-bearing period because of older age at marriage. Another reason is that they are not willing to

TABLE 6

Number of children of college graduates (2)

	Men		Women	
Class	Number of colleges	Per graduate	Number of colleges	Per graduate
1921	35	1.76	38	1.43
1922	29	1.72	33	1.35

have more children than can be provided with the opportunities which they consider desirable. At present a trend toward earlier marriage among those in college seems to be occurring.

The composition of a population can change rapidly. If 10% of the population has four children to the family; 30%, two; and 60%, one, it is only about five generations until the 10% has become 90% and the 60% a little more than 0.5% of the population *(4)*.

Life Expectancy Increasing

Age composition of the population has important relations to many problems, especially those in the medical and labor areas. In the United States the death rate decreased from 13.2 per 1,000 in 1915 to 9.6 in 1954. In general until the last few years the birth rate declined. The average expectation of life increased greatly (Table 7). In 1900 the average life expectancy was about 48 years for men and 51 for women. By 1950 this had changed to 66 years for men and 72 for women. These changes were caused primarily by a decrease in infant mortality and increased life expectancy among the young. In Table 8 is given the percentage distribution of different age groups from 1840 to 1950.

TABLE 7

Average expectation of life among U. S. white population (11)

Time	Male	Female
1900-02	48.2	51.1
1919-21	56.3	58.5
1929-31	59.1	62.7
1939-41	62.8	67.3
1949-51	66.3	72.0

Higher Per Cent of Population in Older Age Group

Less than a century ago a little more than half of the population was under 20 years of age. In 1950, 33.9% of the people were under 20 years of age and 66.1% in the older group. Those over 65 increased from 2.5% in 1840 to 8.1% in 1950.

TABLE 8

Age composition of the population of the United States (8, 11)

	Percentage distribution					
Year	0-19	20-29	30-44	45-64	65+	20+
1840	54.6	18.2	15.7	9.0	2.5	45.4
1850	52.5	18.5	16.6	9.9	2.6	47.5
1860	51.2	18.2	17.4	10.4	2.7	48.8
1870	49.7	17.7	17.7	11.9	3.0	50.3
1880	48.1	18.3	17.6	12.6	3.4	51.9
1890	46.1	18.3	18.6	13.1	3.9	53.9
1900	44.4	18.3	19.5	13.7	4.1	55.6
1910	42.0	18.8	20.3	14.6	4.3	58.0
1920	40.8	17.4	21.0	16.1	4.7	59.2
1930	38.8	16.9	21.5	17.5	5.4	61.2
1940	34.4	17.2	21.7	19.8	6.8	65.6
1950	33.9	15.7	21.9	20.3	8.1	66.1

Increase in age of the population has created new problems for the medical profession. In the past, major interest in the medical field was in connection with infectious diseases, such as typhoid, diphtheria, tuberculosis, and pneumonia, in which living organisms are involved. Remarkable success in controlling such diseases has been attained. Mortality from some of these diseases has been almost eliminated and in others greatly reduced. Death rates from various diseases from 1900 to 1951 are given in Table 9. Noninfectious diseases, those due primarily to malstructure or malfunctioning of tissues and organs of the body, have become the major cause of death. Many of these are diseases of older age groups. Also, heredity is a major influence in many of these noninfectious diseases. Some are directly inherited, and accurate predictions can be made concerning the appearance of such inherited diseases among the children of given parents. In others, heredity is an influencing factor, though the modes

TABLE 9

Death rates from various diseases per 100,000 population (11)

Cause of death	1900	1910	1920	1930	1940	1946	1951
Pneumonia and influenza	202.2 (1) [a]	155.9	207.3	102.5	70.1	44.6	35.2 (4) [a]
Tuberculosis	194.4 (2)	153.8	113.1	71.1	45.8	36.4	20.1 (6)
Diarrhea, enteritis, etc.	142.7 (3)	115.4	53.7	26.0	10.3	5.8	5.0 (7)
Heart disease	137.4 (4)	158.9	159.6	214.2	291.9	306.8	326.9 (1)
Cancer	64.0 (6)	76.2	83.4	97.4	120.0	130.1	137.8 (2)
Diabetes mellitus	11.0 (9)	15.3	16.1	19.1	26.5	24.8	28.5 (5)
Diphtheria	40.3 (7)	21.1	15.3	4.9	1.1	0.9	0.2 (8)
Typhoid, paratyphoid	31.3 (8)	22.5	7.6	4.8	1.1	0.3	0.1 (9)
Brain lesions, vasc.	106.9 (5)	95.8	93.0	89.0	90.8	89.8	91.7 (3)

[a] Figures in parentheses indicate the order of causes of death.

of inheritance are not known. Alleviation may be found, such as insulin in diabetes, which may eliminate symptoms of the disease. Cure in the sense that the hereditary constitution is changed is not possible, as the genes that are associated with noninfectious diseases are not eliminated but are passed on to the next generation.

These changes in the age of the population have an important relation to problems in the field of labor. For example, with a population of 160,000,000 and the numbers of people under and over 20 years of age equal, 80,000,000 would be in each group. In 1950 with 33.9% in the younger group and 66.1% in the older, these numbers would shift to 54,000,000 in the younger group and 106,000,000 in the older. This is an increase of 26,000,000 in the older ages, increasing greatly the number in the working age group. If this 106,000,000 is reduced by subtracting the number in the group above 65 years of age, 94,000,000 still are left. This is an increase of 14,000,000 above that which would have existed if equality of those under 20 and over 20 years of age had been maintained. Under usual economic conditions this change is conducive to unemployment. However, if the age of the population increases enough, the number of dependent old people may become large enough to offset the decrease in the number of dependents in the younger age groups. This equilibrium may be reached some time in the future. This will be influenced by changes in the birth rate and death rate, and in life expectancy among the old.

Population Trends May Be Significant

It seems obvious that biological factors, such as birth and death rates, increase in population, and increase in age of the population, affect or create many social and economic problems. "Can population be controlled?" is a question which is often asked. The answer is yes, at least to some extent. The important question is "how?" Theoretically it could be controlled through programs devised to limit the birth rate. Because of political and religious pressures this method of limitation may never be put into operation. If this is true, the only general method left is through the operation of natural forces uncontrolled by man, such as disease and famine. As the world population increases, the power of these natural forces will increase, causing increasingly greater death rates in the future, unless they can be offset by increased standards of living.

When a population increases to a level where there is not enough work for full time employment at maximum production, economic confusion follows. Attempts are being made to shorten hours of labor, reduce production per capita in order to spread work, guarantee economic security, control prices and production of consumer goods, and maintain income for the producer. All of this if pursued far enough would lead to state control. Will this insure permanency of a social order?

Can a More Abundant Life Be Legislated?

Many countries throughout history have attempted to provide a more abundant life by various kinds of regulations. Miss Lacy *(3)* has written the following: "The history of government limitation of price seems to teach one clear lesson; that in attempting to ease the burdens of the people in a time of high prices by artificially setting a limit to them, the people are not relieved but only exchange one set of ills for another which is greater. Among these ills are (1) the withholding of goods from the market; (2) the dividing of the community into two hostile camps, one only of which considers that the government acts in its interest; (3) the practical difficulties of enforcing such limitation in prices which in the very nature of the case requires the cooperation of both producer and consumer to make it effective." One of the greatest sources of power lies in the control of essential food supplies, and those who have such control have control of the people.

Cooperation by individuals to obtain desirable conditions through their combined creative labors and efforts is a sign of strength. Desiring and depending on contributions from a government are major symptoms of weakness in a social order. Morality, ethics, and high quality of any kind can never be brought into existence by legislation and monetary gifts. They can be attained only through the intelli-

gent desires and efforts of individuals. One generation builds upon what is left by the preceding generation. If the foundation is not sound, it is like the house upon the sands—the rains came, the winds blew, and the house fell.

The world is governed by ideas. If these ideas are mainly concerned with technological processes, there may not be much hope for world betterment. If we can concentrate ideas on the more fundamental problems of man, there is hope for improvement and an increasing quality in the behavior of man. In general, technological advances create problems which in their nature become problems for the social sciences. If this is true, much more concentration on the social sciences would be profitable. It is not merely a study of behavior patterns, however necessary this may be, but research into methods by which behavior can be changed for the good of human society as a whole. The biological aspects of these problems should not be ignored.

Decline in the quality of a people may be through the elimination in one way or another of the more able types. Lowered quality can be the result of decreased fertility, liquidation of those who do not agree with the state, as has occurred in some countries, and making it difficult or impossible through state control for the more able to be creative.

Survival of a society depends upon the quality of the individuals of which society is composed. This quality cannot be attained by legislation—legislation for what is generally called a more abundant life for the people. This more abundant life must be earned; it cannot be given. Individuals must assume responsibility not only for their own personal improvement but for the improvement of the social organization of which they are members. This requires a sense of personal responsibility, which at present seems to be at a lower level than it has been for some time. Because one was not consulted before birth is thought by some to be enough reason to demand care from cradle to grave. This idea was put to Eugene Davenport, former dean of the College of Agriculture of the University of Illinois, by a fellow traveler in this way: "I did not ask to be born into the world; here I am, and the world owes me a living! What do you think of it?" The Dean replied that he had an opinion on the matter which was, "I did not ask that you be born into the world; here you are, and I am not going to make a living for you." Certainly everything possible should be done to care for the incapacitated and to provide conditions in which the individual may have the opportunity to develop to the maximum the innate potentialities which he possesses. One of the most dangerous fallacies of our time is the idea that by legislation conditions can be provided which will result in all individuals realizing the same level of performance. Such might be expected if individual differences were only the result of different environments. The only help for people now living is through the environment, but the fundamental improvement of future generations lies primarily in bringing together better hereditary material.

We proceed on the assumption that our social and economic ills are the result of bad environmental conditions. May not the behavior of man be in large measure the cause of undesirable environmental conditions? Of course the two are interacting, but it is fallacious to assume that environment is the only cause. Individuals, and not the state, should assume responsibility for social changes. At this point, it may be determined whether we shall progress toward permanency or whether our civilization will be like cultures of the past, which flourished for a time and then declined.

Many of our present-day problems had their beginning in the far distant past, and some of the things we are doing today will result in problems for the future. The situation is a challenge, but man has sufficient information, sufficient intelligence, and sufficient quality to meet it successfully—if he will.

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JOURNAL OF DAIRY SCIENCE

ABSTRACTS OF LITERATURE

W. O. Nelson, Abstract Editor

ANIMAL DISEASES

1. Reproductive efficiency and serological findings in heifers experimentally infected with Vibrio fetus. W. N. PLASTRIDGE, H. L. EASTERBROOKS, L. F. WILLIAMS, E. M. KIGGINS, and E. WALKER, Storrs Agr. Expt. Sta., Storrs, Conn. Am. J. Vet. Research, **16**, 61: 493. 1955.

Ten dairy heifers stabled together, but isolated from other cattle were exposed to *V. fetus* cultures by swabbing the cervix of 4, the vulva of 4, and allowing normal contact of the other 2 with the 8 artificially exposed. Blood and cervicovaginal mucus samples were tested for agglutinins at 1 to 2 wk. intervals. Initial exposure was one mo. before breeding. All breedings were by artificial insemination with streptomycin-treated semen from a non-infected bull. All of the cervically exposed heifers were immediately infected, and they required an average of 6.2 services before achieving conceptions followed by normal calving. Three of the four heifers had abortions at 2 to 3 mo. Two of the heifers exposed only by vulvar swabbing also became infected. Two of the non-infected heifers later established infections which could have occurred only due to external contact. The non-infected heifers required 3.3 services per conception. Of 8 infected heifers, 5 recovered in 8 to 14 mo. The others either remained infected for 18 mo. or were repeatedly reinfected. Agglutinins appeared in the cervical mucus and blood of all infected heifers, but were not always present in both blood and mucus. When the infection was well established in the uterus it often produced only blood agglutinins. E. W. Swanson

2. Preliminary studies on pseudomonas mastitis. M. J. DEUBLER and E. J. COLE, Univ. of Pa., Philadelphia. Am. J. Vet. Research, **16**, 61: 511. 1955.

Milk samples from quarters of cows in herds known to have had pseudomonas mastitis were cultured regularly to detect the infection. Of 147 isolated pseudomonas organisms 29 did not yield pigment. All produced acid from glucose but not from lactose, were urease negative and produced trimethylamine. The repeatability of isolations from known infected quarters was unsatisfactory. For this reason the use of blood and milk serum agglutinin titers was tested, and recommended as a means of diagnosis of active infections. Polymyxin B and chloramphenicol were most effective in control of *in vitro* growth of pseudomonas. Neomycin also was effective, but streptomycin, chlortetracycline and oxytetracycline were relatively ineffective in milk media. E. W. Swanson

BOOK REVIEWS

3. Cattle Fertility and Sterility. S. A. ASDELL, Little, Brown and Company, Boston and Toronto. 227 pp. $5.50. 1955.

This 12 chapter book is an expansion of lectures presented by the author at the Royal Veterinary College in London on a Special Lectureship in 1953. The first chapters cover the anatomy and histology of the reproductive organs of the bull and the cow. Following this is a short chapter on the development of the genitalia. The author then devotes 3 chapters to the estrous cycle and its control and estrus, ovulation, and timing of service. A chapter on the properties of semen is next, followed by one on pregnancy and one on hormone levels. The last 3 chapters deal with infertility and sterility from the standpoint of nonpathological factors, disease factors, and finally functional sterility and embryonic mortality.

The book is especially strong in its treatment of reproduction and reproductive problems involving the cow. One criticism that might be leveled at the book is that it is not as strong concerning normal and abnormal reproductive conditions in the bull. Also, the parts dealing with semen for artificial breeding is somewhat abbreviated. Even though more information along these lines would be desirable, it does not detract from the completeness of many of the other aspects considered in the book. While the subject matter necessitates the use of many technical terms, the book is written in a language that should be readily understandable to those interested in this specialized field. A number of good figures, illustrations, and tables are included.

There are numerous references to the work of other investigators and a list is included at the end of each chapter. The book should be a valuable addition to the bookshelf of the many people who must deal with reproductive problems in cattle. N. L. VanDemark

4. Methods of Analysis—ADAC—8th Ed. Association of Official Agricultural Chemists, P. O. Box 540, Benjamin Franklin Station, Washington 4, D. C. 1008 pp. $12.00. 1955.

A new edition of this manual has appeared at 5-year intervals since 1920. New revisions have always reflected progress made in analytical agricultural chemistry. The association has sought to present standardized analytical procedures proven reliable and reproducible.

The latest edition incorporates a number of additions as well as deletions. Significant is the greater emphasis placed on instrumental technics. A new chapter is devoted to spectrographic methods, and flame photometric technics for sodium and potassium in plants appear for the first time. The microchemical chapter has been expanded by standardized methods for elemental analyses of bromine, chlorine, carbon, hydrogen, and sulfur. Chromatographic technics for separation of certain substances are finding wider application.

Noteworthy is the deletion of permissible variations in the Kjeldahl method for nitrogen. A single catalyst, mercury, and certain other experimental details are now prescribed.

A few changes are to be found in the chapter on dairy products. Certain procedures such as those for acidity, ash, casein, and the phosphatase test in milk have undergone a change in designation from "First Action" to "Official." Method I for sample preparation of butter was deleted. A rapid method for the determination of water-insoluble fatty acids was introduced under "First Action" designation. An official procedure for the critical temperature of dissolution of butter fat was included. A modification is indicated for the determination of gums in soft curd cheese. There are also certain minor changes in wording in some tests.

The chapter on Extraneous Materials contains an official sediment test of milk and a series of first action tests for the determination of filth in a number of dairy products.

J. Tobias

5. Protective Coatings for Metals, 2nd Ed. R. M. Burns and W. W. Bradley. Reinhold Publishing Corporation, New York. 1955.

The second edition of this Monograph, which first appeared 15 years ago, has been rewritten. This has been necessitated because of the great developments in the protective coating field brought about by the needs of war and industrial expansion which have given rise to hundreds of new and better protective coating materials.

The present volume, like its predecessor, has been designed for those who have problems of protection. It is not intended to be a manual for the production of protective coatings, although considerable information is given on this phase, but that the reader may have a better understanding of the various coatings and why they behave as they do. Also the frequent reference that is made to the nature of corrosion reactions is helpful in suggesting preventive measures for the solution of specific problems.

The 18 chapters contain a wealth of material amply footnoted and a number of tables and figures. A partial listing of chapters of particular interest to the dairy industry are: 1. Principles of Corrosion and Corrosion Control; 2. Surface Preparation for Coatings; 3. Types of Metallic Coatings and Methods of Application; 4. Sprayed Metal Coatings; 8. Tin Coatings; 9. Nickel and Chromium Coatings; 12. Methods of Testing Metallic Coatings; 13. Organic Coatings. Chemistry and Composition; 14. Organic Coatings. Performance and Evaluation; 15. Application and Use of Protective Organic Coatings; 17. Special-Purpose Coatings; 18. Corrosion Inhibitors. An 8-page Author Index follows the last chapter.

L. M. Dorsey

6. Drying and Dehydration of Foods. 2nd Ed. Harry W. vonLoesecke. Reinhold Publishing Corporation, New York, N. Y.

The 12 years that have passed since the first edition was published have been rich in research which has brought about new techniques in the drying and dehydration of foods, and the creation of new products. The author's idea is to present an integrated survey rather than an exhaustive treatise of the science of food dehydration, a book which will be useful to chemical engineers and food processors. The chapters carrying primary interest to the dairy industry are, 1. Types of Dehydrators, 4. Dehydration of Eggs, Milk, Butter, and Cheese, 7. Plant Sanitation, 8. Nutritive Value of Dried and Dehydrated Foods, 9. Packaging and Storage, 10. Rehydration of Dehydrated Foods; Some Analytical Methods. The analytical methods described are for products other than milk and milk products.

L. M. Dorsey

7. Margarine. A. J. C. Andersen. Pergamon Press Limited, London. 1954.

The author has been actively engaged in or closely associated with the margarine industry for close on half a century which covers the latter half of the industrial development of margarine which had its start in 1869. While the illustrations of the book are nearly all of European and British margarine machinery one 10-page section devoted to the Votator process of the Girdler Corporation is found in Part III., The Process, under Continuous Processes wherein the illustrations and diagrams originated in the U.S.A. However, the book in 7 parts presents a valuable source of information on margarine particularly along the line of the modern developments, the majority of which have had their origin in England and the Continent. The main parts are: I. Introduction and History; II. Raw Materials; III. The

Process; IV. Storage and Preservation of Margarine; V. Process Control; VI. Margarine Legislation; VII. Factory Plans. There are 105 figures constituting equipment photographs and diagrams, physical property graphs, and factory plans and elevations.
L. M. Dorsey

8. Principles of Industrial Waste Treatment. C. Fred Gurnham. John Wiley & Sons, Inc., New York, N. Y. 1955.

Written primarily for students, this book discusses the liquid wastes produced by industry, the sources of these wastes, their pollutional effects, and methods for their treatment and disposal. The 24 chapters are illustrated with 58 figures comprising photographs, diagrams, and charts. Early chapters of the book describe pollutional effects of industrial wastes in streams and sewers, and criteria developed by the sanitary engineer for evaluating pollution. This is followed by discussion of operations and processes used to treat industrial wastes before discharge into natural waters or municipal sewers. The last chapter includes brief descriptions of some process industries that have major waste disposal problems, among them the dairy industry. Altogether dairy wastes are alluded to 14 times in the text. A good source of basic information for the dairy industry executive. L. M. Dorsey

BUTTER

9. Water-insoluble acids, butyric acid, and fat acidity of butter as related to quality. C. E. Parmelee and F. J. Babel, Purdue Agr. Expt. Sta., Lafayette, Ind. Sta. Bull. 603. 1953.

The amount of WIA (water-insoluble acids) in butter is affected by the amount of NaOH added to the fat-water-ether mixture during neutralization. An increase in WIA is generally accompanied by an increase in the amount of NaOH used in neutralization. The amount of WIA in butter prepared from fresh milk was not related to season of year, breed, or stage of lactation. Raw sweet cream preserved with formaldehyde had lower WIA and butyric acid values than cream saturated with sugar.
R. W. Hunt

10. Device for making butter. E. Nanz (assignor to Societe Pour l'Equipment des Industries Laitieres et Agricoles [S.E.I.L.A.] and W. J. Sidler). U. S. Patent 2,721,062. 2 claims. Oct. 18, 1955. Offic. Gaz. U. S. Pat. Office, **699**, 3: 481. 1955.

A continuous butter churn consisting of a horizontal cylindrical chamber and two sets of dashers or vanes which may be operated independently of each other. A milk or cream inlet is provided. The butter is discharged continuously by action of one set of vanes, through an outlet. R. Whitaker

11. Butter slicer. A. Janossy. U. S. Patent 2,723,454. 8 claims. Nov. 15, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 3: 399. 1955.

A device for slicing prints of butter into individual pats. R. Whitaker

12. Churn agitator. N. C. Dorrough. U. S. Patent 2,716,545. 1 claim. Aug. 30, 1955. Offic. Gaz. U. S. Pat. Office, **697**, 5: 638. 1955.

A shaft, adjustable in length and equipped with propeller-like blades, is described for use in small vertical cylindrical-shaped churns.
R. Whitaker

13. Automatic butter pat former and dispenser. E. Fromwiller. U. S. Patent 2,718,-701. 8 claims. Sept. 27, 1955. Offic. Gaz. U. S. Pat. Office, **698**, 4: 537. 1955.

Butter in block form is cut and continuously dispensed in pats onto paper plates.
R. Whitaker

14. Packages and packaging articles. D. Melnick (assignor to The Best Foods, Inc.). U. S. Patent 2,724,650. 11 claims. Nov. 22, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 4: 711. 1955.

A wrapper for butter and margarine made from wax coated paper. The wax has a melting point of between 125° and 165° F. and contains a fungicide, characterized as edible, fat soluble, and steam distillable, and comprising a carboxylic acid having a double bond hydrocarbon group adjacent to the carboxyl group. R. Whitaker

CHEESE

15. Paraffin and microcrystalline waxes as cheese coating materials. O. R. Irvine, D. H. Bullock, and R. E. Emond, Ont. Agr. Coll., Guelph, and Imperial Oil Research Laboratories, Sarnia, Canada. Can. J. Agr. Sci., **35**, 2: 153. 1955.

Petroleum waxes of varying physical properties were examined as cheese coating materials. Test slices of Cheddar cheese, after immersion in hot wax, were examined for thickness of wax film, wt. loss over 30-d., resistance to impact damage, and control of mold growth. Two batch-produced waxes and one of the semi-commercially prepared waxes gave superior protection to cheese as compared to refined paraffin. However, wt. losses were slightly lower where commercial cheese waxes were used.

The effects of varying times and temperatures of application upon the protection afforded to cheese by two types of wax were determined. Blends of paraffin and microcrystalline wax, as well as waxes containing admixtures of mineral oil, were also studied. Some waxes imparted undesirable flavor to cheese.

Three groups of triplet-size Cheddar cheese were given different wax treatments, and

shrinkages determined after 11 mo. storage. Double-coated cheese lost significantly less wt. and rinds remained in excellent condition.
O. R. Irvine

16. A market survey of cottage cheese. L. G. HARMON, G. M. TROUT, and M. D. BONNER, Mich. Agr. Expt. Sta., East Lansing. Quart. Bull., **38**, 1: 146. 1955.

Cottage cheese purchased in retail stores and held at 42° F. showed a shelf-life of from 5 to 19 days for 48 samples, and from 6 to 23 days for 35 samples. The shelf-life of 17 samples of cottage cheese obtained from the processors' vats was 51.38% longer when stored at 42° F. rather than 50° F. Considerable variations between daily temperatures were encountered in display cabinets. Large temperature differences, as much as 14° F., were also found between the top and bottom of the cabinet.
R. W. Hunt

17. Dozen-day shelf-life for cottage cheese, S. L. TUCKEY, Dept. of Food Technol., Univ. of Ill., Urbana. Food Eng., **27**, 10: 92. 1955.

Results of surveys on quality of cottage cheese at retail level indicate the need for greater attention to: (1) quality of raw product, (2) processing techniques, and (3) sanitation procedures. Defects arise from development of microorganisms in the product, faulty manufacturing procedures, alkaline chemical compounds, and off flavors in milk. The surveys showed that a high proportion of cottage cheese samples were contaminated with psychrophilic organisms, which grow at storage temperatures for cottage cheese. The chief sources of contamination are equipment and wash water. Chlorination of water supplies is indicated as a control measure. The fact that about 25% of the manufacturers represented were able to produce cheese without excessive contamination indicates that such condition is practicable and attainable. T. J. Claydon

18. Manufacturing a process cheese loaf utilizing daisy cheese and curd from nonfat dry milk. C. R. BARKER, Oak Park, Illinois. Milk Prod. J., **46**, 11: 20. 1955.

The author presents details for manufacturing a process cheese loaf with 50% nonfat dry milk curd, 25% old English daisy cheese, and 25% new daisy cheese.

The curd was made up, using 5½ lb. of powdered nonfat milk, 19¾ lb. of warm water at 95° F., 214 g. bulk starter, 56 g. pure lactic acid, 3 g. of rennet, 20 g. of cold water, and 84 g. of fine salt. Specific details of manufacture of these experimental batches are presented.

Two separate formulas are given for the preparation of a processed cheese loaf. Minor ingredients include sodium citrate, di-sodium phosphate, cayenne pepper, chopped pimientos, and fine salt. J. J. Janzen

19. Cheese mixer. S. BOWMAN. U. S. Patent 2,721,063. 2 claims. Oct. 18, 1955. Offic. Gaz. U. S. Pat. Office, **699**, 3: 481. 1955.

A U-shaped mixer designed especially for processing cheese. R. Whitaker

CONDENSED AND DRIED MILKS; BY-PRODUCTS

20. Concentrate consumption grows in Iowa. V. H. NIELSEN and W. S. ROSENBERGER, Iowa State Coll., Ames. Milk Plant Monthly, **44**, 10: 20. 1955.

An increase in per capita milk consumption of 30 to 50% has been registered in the past three years by families who have been using a fresh milk concentrate developed at Iowa State College. About 400 rural families in the Ames, Iowa, area have been using the product during the three-year period. Total milk consumption in the area increased from 9,300 to 24,600 pt. a month. In a grade A milk plant already operating and to which the fresh milk concentrate was added, the cost range for the same volumes would be from 25¢ to 9.7¢. Assuming the concentrated milk operation is added to a manufacturing plant, the costs would range from 49.9¢ to 10.3¢/qt of concentrate. The cost of delivery per unit of sale is 3.56¢.

A frozen concentrated milk product has been prepared using essentially the same procedure except that the concentrated product is pasteurized at 165-170° F. prior to cooling and canning. The essential factors in the successful production of the frozen concentrate are: (1) A high quality grade A milk supply, (2) Stainless steel processing equipment in good mechanical condition, (3) Second heat treatment of the milk after it has been concentrated, (4) Solids content of the concentrate should not exceed 36%, and (5) Temperature of freezing and subsequent storage must be maintained at– 20° F. if the concentrated milk is stored for a period of more than two weeks.
C. J. Babcock

21. Fermentation. S. C. BEESCH and G. M. SHULL, Chas. Pfizer & Co., Brooklyn 6, N. Y. Ind. and Eng. Chem., **47**, 9: 1857. 1955.

New developments in the fermentation field are discussed in this unit process review. Whey is a fermentation medium which furnishes a source of nitrogen and carbohydrate. Antibiotics, food, feed, and enzymes are important fermentation products. B. H. Webb

22. Process of preparing an aluminum caseinate. L. O. PATERSON. U. S. Patent 2,721,-861. 6 claims. Oct. 25, 1955. Offic. Gaz. U. S. Pat. Office, **699**, 4: 686. 1955.

An aluminum caseinate is formed from an ionizable Al salt and Al hydroxide by suitable pH adjustment between the isoelectric point of the protein and about pH 7. The Al caseinate is used as an anti-acid. R. Whitaker

23. Dried or evaporated food products, especially milk and the process of making it. H. A. TOULMIN, JR. (assignor to The Commonwealth Engineering Co.). U. S. Patent Reissue 24,080. 6 claims. Oct. 25, 1955. Offic. Gaz. U. S. Pat. Office, **699**, 4: 553. 1955.

A method for producing concentrated milk by separating ice from a frozen slush. The concentrate may be later spray dried. Described previously in J. Dairy Sci., **36**, 11: A137. (Abstr. 980). R. Whitaker

24. Dispenser for concentrates and the like. C. C. BAUERLEIN (assignor to The Dole Valve Co.). U. S. Patent 2,716,996. 9 claims. Sept. 6, 1955. Offic. Gaz. U. S. Pat. Office, **698**, 1: 70. 1955.

The important feature of this dispenser is a unique valve which automatically mixes a proportional amount of concentrate of milk, fruit juice, or other beverage base with water to yield a reconstituted drink ready for serving. A source of potable water is piped to a cooling coil in the dispenser. When a serving of the product is desired, a magnetic-operated valve is actuated which admits a measured quantity of water to flow through the mixing valve. This flow of water draws in a measured amount of concentrate and the mixture is discharged directly into a cup or glass. R. Whitaker

25. Dehydrated whole milk product and the process of producing the same. J. H. ROLLINS and H. R. TURNER. U. S. Patent 2,719,792. 9 claims. Oct. 4, 1955. Offic. Gaz. U. S. Pat. Office, **699**, 1: 141. 1955.

Whole milk is separated into skimmilk and cream. Starch is added to the cream to absorb the fat, and the blend is mixed with the skimmilk. After drying this mixture, the powder grains are coated with a mixture of tapioca starch, methyl cellulose, and lactose.
R. Whitaker

DAIRY BACTERIOLOGY

26. Resistance of calf scour-producing organisms to broad spectrum antibiotics. F. S. BARR, P. E. CARMAN, and T. B. CLARKSON, S. E. Massengill Co., Bristol, Tenn. Am. J. Vet. Research, **16**, 61: 515. 1955.

Cultures of *P. aeruginosa*, *Salmonella*, and three different strains of *E. coli* were isolated from scouring calves which had previously been treated for other diseases with broad spectrum antibiotics. These cultures were tested for resistance against oxytetracycline, tetracycline, chlortetracycline, neomycin, polymyxin, and a mixture of neomycin and polymyxin. From 500 to 1,000 μg/ml of the tertracycline group were required to inhibit the organisms, while 2.5 to 35 μg/ml of polymyxin or neomycin were effective. The possibility of a developed resistance to the tetracycline group of antibiotics was suggested, but these trials did not prove that such developed resistance had occurred.
E. W. Swanson

27. Chromatographic studies on proteolytic bacteria in their relationship to flavour development in Cheddar cheese. A. R. YATES, O. R. IRVINE, and J. D. CUNNINGHAM, Ont. Agr. Coll., Guelph, Ont. Can. J. Sci. Agr., **35**, 4: 337. 1955.

A series of 350 bacterial cultures isolated from cheese factory sources were examined for proteolytic activities when incubated at 13° C. for 21 d. Paper chromatography showed that certain isolates were capable of liberating leucine and other amino acids from rennet-digested skimmilk but not from sterile skimmilk. Cultures identified as *S. lactis*, *S. cremoris*, *S. liquefaciens*, *L. casei*, and *S. lutea* possessed this ability to a greater degree than the remaining isolates. These were added to pasteurized milk and made into Cheddar cheese to determine their cheese flavor stimulating powers. After 3 to 10 mo. curing, vats containing *L. casei* and *S. lutea* had more flavor and better texture than the control lots. *S. liquefaciens* produced bitter flavors and weak-bodied cheeses while vats containing added *S. lactis* and *S. cremoris* cultures were similar to the controls.
O. R. Irvine

28. Studies in the cold sterilization of liquid foods using mercury resonance radiation. I. Milk. J. J. ALBRECHT, H. E. GUNNING, and M. E. PARKER, Ill. Inst. of Technol., Chicago. Food Research, **20**, 5: 424. 1955.

A rather complete review of the effects of radiant energy on milk is presented, along with a number of experiments wherein raw milk was irradiated at 40° F. while flowing through a special cell of optical quality fused quartz. The source of radiation was a Hanovia "Biosteritron" type lamp emitting about 90% of the arc output at 2537 Å, and about 9% at 1849 Å. Substantially zero bacterial plate counts were obtained with an input lamp energy of 75 watts and an exposure time of 10 sec. "Activated" flavors were encountered in the treated milk which apparently varied in susceptibility from lot to lot. Inoculations of *S. lactis* prior to irradiation reduced the degree of activated flavor appearing in the milk. The authors believe that sterile milk without objectionable flavor is possible with further study of the method. F. J. Doan

29. Observations on the presence of facultative psychrophilic bacteria in milk produced under the farm tank system. C. C. PROUTY, Dept. Dairy Sci., State Coll. of Wash., Pullman. J. Milk and Food Technol., **18**, 10: 250. 1955.

Facultative psychrophilic plate counts at 17° C. in raw milk produced under the farm tank system were compared with the standard plate counts at 35° C. and at 37° to 39° F.

During the storage period the facultative psychrophilic counts increased more rapidly than the standard plate counts. After 48 hr.

of storage 25.5% of the samples had psychrophilic counts in excess of 100,000 per ml.

There were marked differences in the initial levels of bacteria counts for psychrophilic and mesophilic types of organisms during the storage of the milks from three dairy farms.

H. H. Weiser

30. Inhibitory substances in milk. H. H. Wilkowske and W. A. Krienke, Fla. Agr. Expt. Sta., Gainsville. J. Milk and Food Technol., **18**, 10: 254. 1955.

The infrequent presence of bacterial growth inhibitors in raw milk has been reported. Residues from chemical sanitizers, "sulfa" drugs, antibiotics, and bacteriophages may cause lowered plate counts and retarded lactic acid production. However, none are satisfactory as milk preservatives, since none are effective against all types of bacterial spoilage. The use of antibacterial agents should not be allowed because such use might cover up poor quality milk, poor production on the farm, and poor processing methods in the plant. Milk intended for human consumption should be free of bacterial growth inhibitors.

The widespread use of antibiotics in treatment of mastitis has been fully justified, but their indiscriminate use in treating dairy herds should be discouraged. H. H. Weiser

31. A modified disc assay method for detecting antibiotics in milk. J. Cerny and R. L. Morris, Iowa State Dept. of Health, Iowa City. J. Milk and Food Technol., **18**, 11: 281. 1955.

Difco dehydrated whey agar was distributed in 100 ml. portions in glass containers and sterilized. The medium was cooled to 50-55° C. and each 100 ml. portion was inoculated with 1 ml. (1 ampule) of standardized inoculum culture (ATCC 6633, Subtilis spore suspension Bacto B 453). After thorough mixing 6 ml. of the medium was pipetted into a sterile petri dish and allowed to solidify. Two sterile superimposed 0.5 in. No. 740-Es & S filter paper discs were dipped into milk sample which had been heated previously to 180° F. for 5 min. and cooled to room temperature. The plates were inverted and incubated at 37° C. for 8 hr. A clear 360° zone indicates a positive test. There appears to be a reasonable correlation between zone diameter and antibiotic concentration. H. H. Weiser

DAIRY CHEMISTRY

32. Quantitative determination of amino acids by circular paper chromatography. K. Krishnamurthy and M. Swaminathan, Centl. Food Technol. Research Inst., Mysore, India. Analyt. Chem., **27**, 9: 1396. 1955.

A procedure for the separation of 16 amino acids from a mixture, on a series of circular paper chromatograms by using different solvent mixtures is described. The chromatograms of the unknown amino acid mixture and known mixture of standard amino acids are developed side by side on the same paper. For the quantitative determination of the amino acids the chromatograms are treated with ninhydrin and the colored bands due to each amino acid in the standard and unknown chromatograms are cut. The color is extracted with 5 ml. of 75% alcohol and estimated in a Klett-Summerson photoelectric colorimeter using 560 $m\mu$ filter. The method yields highly reproducible results in the determination of the amino acid content of casein, in agreement with those reported by other workers. B. H. Webb

33. Rumen chemistry, in vitro studies with rumen microorganisms using carbon-14-labeled casein, glutamic acid, leucine, and carbonate. K. K. Otagaki, A. L. Black, H. Goss, and M. Kleiber, Dept. of An. Husb. and School of Vet. Med., Univ. of Calif., Davis. J. Agr. and Food Chem., **3**, 11: 948. 1955.

Previous studies have indicated that metabolic activity of microorganisms in the rumen of cattle and sheep is not limited to cellulose and fermentable carbohydrates but also involves proteins and amino acids. This investigation was undertaken to trace further the fate of proteins and amino acids in the rumen of sheep using compounds labeled with C^{14}. *In vitro* studies with rumen microorganisms incubated with C^{14}-casein, glutamic acid, leucine, and carbonate indicated that proteolytic enzymes are active in rumen fluid and that deaminases and transaminases are present for decomposition of amino acids. The fixation of carbon dioxide in both essential and non-essential amino acids was demonstrated.

S. Patton

34. Margarine. P. L. Julian, H. T. Iveson, and M. L. McClelland (assignors to The Glidden Company). U. S. Patent 2,724,649. 7 claims. Nov. 22, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 4: 711. 1955.

Margarine is made free from spattering and the formation of a sticky residue by the addition of 0.05% alcohol insoluble vegetable lecithins. R. Whitaker

DAIRY ENGINEERING

35. Re-equip and save with centrifugal separation. Staff Editors, Milk Plant Monthly. Milk Plant Monthly, **44**, 10: 30. 1955.

One of the newer innovations in milk processing is cold milk separation. Examples are given of plant usage of this new equipment for higher volume and better quality. Dairy operators find cold milk processing advantageous because it eliminates costly heating equipment that meant higher operating costs, and loss of valuable space that can be better utilized.

C. J. Babcock

36. Electric powered mobile refrigeration gaining momentum. S. E. TOMKINSON, Specialty Component Motor Dept., General Electric Co. Refrig. Eng., **63**, 11: 49. 1955.

At the request of a manufacturer of truck refrigeration equipment the Specialty Component Motor Dept., of the General Electric Co., undertook an engineering study of the basic requirements that should be met to give the customer a good practical truck refrigeration system. The features sought were:

1. Full and constant refrigeration up to capacity of the system at all truck speeds.
2. Full refrigerating capacity at idle speed of the truck engine.
3. Provision for plug-in of commercial power for stand-by.
4. The system to be a compact, light-weight packaged unit easy to install and maintain.

The solution arrived at is discussed in detail.

L. M. Dorsey

37. Article bagging machine. J. L. CHANALES (assignor to Dixon Engineering Co.). U. S. Patent 2,721,015. 30 claims. Oct. 18, 1955. Offic. Gaz. U. S. Pat. Office, **699**, 3: 469. 1955.

A device for placing items, like frozen stick novelties, in bags. R. Whitaker

38. Loading mechanism for frozen confection bagging machines. J. L. CHANALES (assignor to Dixon Engineering Co.). U. S. Patent 2,721,016. 10 claims. Oct. 18, 1955. Offic. Gaz. U. S. Pat. Office, **699**, 3: 469. 1955.

Similar to Abst. No. 37, but giving details for loading the frozen confections from a conveyor into the bagging machine.

R. Whitaker

39. Milk can unloader and recovering unit. F. J. WETZEL (assignor to W. P. Equipment Corp.). U. S. Patent 2,723,792. 3 claims. Nov. 15, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 3: 487. 1955.

A device for up-ending milk cans and placing them on the conveyor leading to a can washer. The lids are placed on an overhead conveyor by hand. R. Whitaker

40. Gas charging machine and method. N. E. SPIESS, JR., L. C. WIDDOES, and K. R. WEAVER (assignors to National Dairy Research Laboratories, Inc.). U. S. Patent 2,723,790. 15 claims. Nov. 15, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 3: 487. 1955.

Cream or other product in a can is charged with a gas by insertion of a hollow needle into the can. The gas under pressure is admitted through the needle and released beneath the surface to provide rapid saturation of the product by the gas. R. Whitaker

41. Bottle cap. I. L. WILCOX (assignor to Oswego Falls Corp.). U. S. Patent 2,718,322. 4 claims. Sept. 20, 1955. Offic. Gaz. U. S. Pat. Office, **698**, 3: 425. 1955.

A cover-all type of milk bottle cap consisting of a disc of flexible sheeting stretched over the bead of the bottle and held in place by a stiff disc pressed over the sheeting into the cap seat and another stiff circular section surrounding the neck of the bottle below the bead.

R. Whitaker

42. Centrifugal separator bowl having nozzles for continuous discharge of separated solids. G. J. STREZYNSKI (assignor to The De Laval Separator Co.). U. S. Patent 2,719,003. 4 claims. Sept. 27, 1955. Offic. Gaz. U. S. Pat. Office, **698**, 4: 614. 1955.

An arrangement of two nozzles in series and an enlarged space between them for discharging the heavier density solids from a separator bowl. R. Whitaker

43. Tubular device for the decapping of containers. W. A. FINLEY (assignor to Supplee-Wills-Jones Milk Co.). U. S. Patent 2,718,801. 8 claims. Sept. 27, 1955. Offic. Gaz. U. S. Pat. Office, **698**, 4: 561. 1955.

Caps may be rapidly removed from bottles of milk by hand use of this tool. It is tubular in shape and larger in diameter than the caps. The caps, dislodged from the bottles by a chuck which passes about the caps, are forced upward into the tube where they accumulate for later discharge from the other end of the tube. R. Whitaker

44. Device for drying washed milk and beverage bottle carriers. J. J. BOCCHINO. U. S. Patent 2,718,714. 1 claim. Sept. 27, 1955. Offic. Gaz. U. S. Pat. Office, **698**, 4: 540. 1955.

Cases for milk or other bottles are dried by air pressure after washing.

R. Whitaker

45. Cream separator disk assembly. H. W. HEIN and W. H. HARSTICK (assignors to International Harvester Co.). U. S. Patent 2,725,190. 1 claim. Nov. 29, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 5: 878. 1955.

Special shaped discs are described which facilitate separation of cream from milk in the bowl of a centrifugal separator.

R. Whitaker

46. Disc type regulator for centrifugal separator bowl. W. H. HARSTICK and H. W. HEIN (assignors to International Harvester Co.). U. S. Patent 2,725,189. 1 claim. Nov. 29, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 5: 878. 1955.

Details are given for a valve regulator for introducing liquids into separator bowls.

R. Whitaker

47. Shock mount for centrifugal separators. W. A. SCOTT (assignor to The De Laval Separator Co.). U. S. Patent 2,725,188. 5 claims. Nov. 29, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 5: 878. 1955.

A mechanism is described which controls the flow of liquid through a tubular feed leading from the shaft of the bowl into the lower part of the bowl. R. Whitaker

48. Centrifuge for the clarification and standardization of milk. G. J. STREZYNSKI (assignor to The De Laval Separator Co.). U. S. Patent 2,725,186. 5 claims. Nov. 29, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 5: 877. 1955.

The fat content of milk leaving this bowl is controlled by the amount of cream which is bled back into the milk outlet.

R. Whitaker

49. Humidity control in the dairy plant. ANON. Milk Dealer, **45**, 2: 42. 1955.

The relative humidity at which paper container stock should be stored ranges from 40% to 60% and the temperature ranges from 60° F. to 90° F. Above these temperatures and relative humidities, the moisture is too high and causes difficulty as it is absorbed into the paper containers. At the lower ranges the paper has a tendency to dry out, which also causes difficulty. C. J. Babcock

50. The vac-heat process. J. T. SMITH and H. L. MITTEN, The Creamery Package Mfg. Co., Fort Atkinson, Wis. Milk Dealer, **45**, 2: 45, 1955.

A description of the Vac-Heat process for controlling volatile flavors and odors in milk. It is an automatically controlled unit used in conjunction with HTST pasteurizer systems. It consists of an atomizing cylinder, vaporization cylinder, steam and condenser equipment, atomizing nozzle, vacuum differential valve, vacuum producing equipment, and automatic safety flow controls. The unit, although relatively inexpensive, permits effective removal from milk of volatile flavors and odors associated with many feeds. C. J. Babcock

DAIRY PLANT MANAGEMENT AND ECONOMICS

51. Consider protein in the pricing of milk. H. L. ANDREWS, H. F. FISHER, and H. C. ANDREWS, The Protein Economies and Research Council, Inc., Ames, Iowa. Milk Dealer, **45**, 1: 58. 1955.

The high dollar value of protein may cause it to eventually be the dominant factor, in determining the price of raw milk, for a cwt. of milk actually contains $5.00 worth of protein. The relative quantities of the food constituents contained in cwt. of 3.5% milk, and the relative worth values of these constituents in dollars and cents if they were bought at alternative wholesale prices or off-the-farm prices are discussed. There is estimated to be in each cwt. of raw milk about 1¢ worth of water; 30¢ worth of sugar; 42¢ to $3.60 worth of fat; $4.80 to $10.40 worth of protein, 10¢ worth of minerals, and 10¢ worth of vitamins. These estimated monetary values are not to be taken as the final word but since buying milk is a dollar and cents operation, it is wise to try and gain from them a fair understanding and comparison of the relative monetary value of the several identifiable constituents. It is clear that at this time the protein and the fat are the most valuable. They are fortunately easily identifiable and easy to test for. C. J. Babcock

52. Milk control programs of the Northeastern states. Part I. Fixing of prices paid and charged by dealers. L. SPENCER and S. K. CHRISTENSEN, N. Y. Agr. Expt. Sta., Ithaca. Bull. 908. 1954.

This bulletin reviews the history of price controls on milk and describes in considerable detail how the present programs are functioning in the Northeastern states. Some of the topics discussed are price policies and objectives, seasonal pricing plans, effect of prices on production, and fixing of retail and wholesale prices of milk. R. W. Hunt

53. Cost of processing and distributing milk in the South. J. C. PURCELL and N. M. PENNY, Miss. Agr. Expt., State College. Sou. Coop. Series, Bull. 45. 1955.

This report analyzes unit costs of 16 dairy plants located in the states of Ga., Miss., S. C., and Tenn. The plants involved had a daily volume of from 8,000 to 43,000 qt. Wages and salaries accounted for 42% of the total processing and distributing costs. Container cost was the second largest item. All major cost items showed a considerable variability among plants suggesting that some plants are operating more efficiently than others. Expenditures for supplies was the greatest variability, followed by equipment costs. Variation between wages paid by the different plants was greatest for executive salaries and distribution labor. Cost reductions with increased volume were most important in the washing, filling, and cold storage functions for products bottled in glass, and in filling and cold storage for products in paper containers. Increased efficiency for increased volume was most important in the filling function for both paper and glass and glass washing. Inefficiencies were traced to (1) poor floor plans, (2) inadequate equipment, (3) partial utilization of labor and equipment, (4) small plant volume, and (5) distribution organization. R. W. Hunt

54. Kentucky's bottled milk industry. J. B. ROBERTS and C. C. ERWIN, Ky. Agr. Expt. Sta., Lexington. Bull. 625. 1955.

Consumption in most areas of Ky. has increased from less than 50% of the total sold in the late 1930's to about 98% in 1954. Its general acceptance is the result of several factors: (1) consumer acceptance of paper

packaged milk, (2) resistance of store owners to handle returned bottles, and (3) pressure of high quality uniformity and variety of products which can be achieved by large centralized milk plants. In addition to their fluid business, most of the 123 plants in Ky. distributed buttermilk, chocolate milk, cottage cheese, and limited amounts of cream, ice cream, and butter. Sales areas which extended 20-40 miles in all directions from the plant were common; routes from 70-100 miles were numerous. At the time of this survey, 37 of the 123 plants operated paper milk container machines. Sales of milk in paper containers amounted to 47.5% of all milk sold.

R. W. Hunt

55. Hood's "break-even" method in delivery. R. A. PHILLIPS, H. P. Hood & Sons, Boston, Mass. Ice Cream Trade J., **51**, 10: 124. 1955.

The "break-even" method of route operation is a system installed by H. P. Hood and Sons, Boston, Mass., to measure the effectiveness of their route delivery system. The break-even point was determined by taking all the costs of operating a branch in 1954 and adding to this any increase costs which could be expected in 1955. This total figure was changed into gal. or units by using ave. gross profit per unit. This figure was divided by the number of routes and by 52 wk. The number of units that had to be sold per route per wk. to break even was determined. This system provides the manager a tool by which he can see what each route is doing and can take immediate corrective action. W. H. Martin

56. The chain of command in quality control. G. H. DAMMANN, J. D. Roszell Co., Peoria, Ill. Ice Cream Trade J., **51**, 8: 26. 1955.

Samples of incoming raw materials should be selected at random and a record maintained, relative to their physical quality, bacteria, yeast, and mold counts. These records help the quality control supervisor to approve products for purchase, or rejection. Correct formulas, processing times, temperatures, and other processing procedures should be determined. Organized quality control provides for finished product examinations, both physically and bacteriologically. Samples should be taken from the production line at random continually and systematically. Keeping quality tests should be made, coliform counts determined, and all equipment should be subjected to sanitary control procedures. Water purity should be checked periodically. The plant should be kept free from insects and rodents. Plants should have a research program as an aid to solving many of the new problems, which contribute to the quality of the finished products.

W. H. Martin

57. Local milk producers' campaign finds success in "self-help" theme. ANON. Milk Dealer, **44**, 12: 44. 1955.

Through 1953 and the early part of 1954, per capita consumption of milk in the greater Washington, D. C. area declined alarmingly. While the 1,950 dairy farmers supplying this market were producing 12.5% more milk, sales had increased only 1.3%. Production control, an anathema to all dairy farmers, seemed for a time to be the only solution to the unfavorable ratio between the production and consumption. However, by abandoning production control as a corrective for an unfavorable production-consumption ratio and instead, expanding their market through "audited" advertising, public relations, and merchandising, the Association found a sane way to dispose of milk, in the market place, where it rightfully belongs. The methods used are described. C. J. Babcock

58. New business for milk dealers. W. R. SANDBERG, Tastee Freez Corp., Chicago, Ill. Milk Dealer, **44**, 12: 48. 1955.

Many milk dealers have found that manufacturing soft-serve ice cream mix is not only profitable but is the perfect complement to their normal operational activities. Others have found unusually handsome profits by acquiring franchise rights from major soft-serve ice cream organizations and have developed their own chain of retail outlets from which they collect substantial gallonage royalties plus long-life profitable mix contracts. C. J. Babcock

59. Route forms for bulk milk pickup routes. ANON. Milk Dealer, **44**, 12: 142. 1955.

A reproduction of a standard bulk milk sheet currently used in the Sheboygan County (Wis.) area. This milk sheet is posted by the truck driver on a board near the producer's cooler. The driver fills in the information the form calls for as he makes his milk pickup. This includes the month, patron number, date, weight, and temperature. Each sheet has space for data covering two complete months.

C. J. Babcock

60. The ABC's of the special school milk program. ANON. Milk Dealer, **45**, 1: 46. 1955.

The government sponsored 50 million dollar special school lunch program moved more than 451 million extra ½-pt. of milk during the first year of operation. The new revised program is expected to move more than one billion extra ½-pt. of milk during the current school year. The program is discussed under (1) What the government is doing to increase further the consumption of milk, (2) What the National Dairy Council and affiliated units are doing to make the program more effective and, (3) What milk dealers should do to help move three billion extra ½-pt. of milk in 1956.

C. J. Babcock

61. Using photography in work simplification. ANON. Milk Dealer, **45**, 1: 48. 1955.

A record of increased productivity of operations and operators in 14 milk plants can be

partly attributed to the use of photography in a work simplification program. Recording operations on film provides many benefits to employees and profits for the company. Among these are an accurate and permanent record of the job as it is being done. Filming gives a "bird's-eye" view of operations for improved housekeeping and safety. It provides a better understanding by supervisors and operators of the inter-relationship of the men and machines involved, and it is also an excellent technique for operator participation. Finally it provides a means of trading information and methods between company management and other companies. C. J. Babcock

62. Twin city goes 100% for bulk pickup. ANON. Milk Dealer, **45**, 1: 152. 1955.

Approval by the majority of the 4,000 shipping members of Twin City Milk Producers Association to switch to bulk milk pickup has made the St. Paul, Minn. organization one of the first of its size to convert entirely to the bulk method. The association has figured that the savings of the producer and the association, with 100% conversion, will pay for the entire cost of bulk tanks over a period of years. The first of the producers' savings is the elimination of cans, which amounts to 1.4¢/cwt. A second savings for the producers is a gain of 2.5¢/qt by eliminating the dumping loss in the can receiving room. The third producer savings is estimated at 5.0¢/cwt in hauling costs. These savings total 8.9¢/cwt to the producers. Furthermore, an increase in the returns from dealers' sales of 2.22¢/cwt is realized by eliminating can washing and receiving costs are reduced 5.57¢. These savings total 7.79¢/cwt. The application of the producer and dealer savings to the purchase of tanks is explained.
C. J. Babcock

63. Small space ads can succeed. STAFF EDITORS, Milk Plant Monthly, Milk Plant Monthly, **44**, 11: 15. 1955.

Dollar-for-dollar good small space advertisements used consistently will produce more business for a milk plant than an occasional large space advertisement. The following suggestions are made for the small space advertiser: (1) Hang it on a peg. One appeal, one dairy product, one type of customer is all a small-space advertisement can cover effectively. (2) Pack power into your headline. Make it specific, keep it short, use large type. Your headline accounts for half your ad's effectiveness. (3) Prune out the frills. Start selling with the first words. Don't use two words when one will do. Substitute short words for long ones. (4) Spotlight your firm's name. The object of small-space advertising is to keep your name in front of your readers. Make your signature distinctive. (5) Frame your small space. Use simple borders to keep your ad from being associated with the one next to it. Don't cut up the ad in sections. (6) Try for good position. Many newspapers have special spots for small ads, if used consistently. (7) Test different sizes and shapes. Find the correct size and shape for your particular message.
C. J. Babcock

64. Milk plants forecast bright vending future. T. D. LEATHERS. Milk Plant Monthly, **44**, 11: 22. 1955.

Questionnaires were sent to 1,000 dairies throughout the country. Fifty-three % of the dairies returning the questionnaires operated at least one vendor and the remaining 47% had not entered the vending business. A bright future for vending was predicted by the plant operators, 54% said it will grow steadily, 24% said it would remain at the present level, 22% said it would increase tremendously and nobody said vending would decline or disappear. Factories and other industrial plants were considered by 47.5% of the dairies as the most profitable location for indoor units. Schools were favored by 27.4%. Service stations were the most popular outdoor locations, followed by busy street corners. The estimated volume per machine that was necessary to break even ranged from 30 to 200 indoor units, and 20 to 500 units for outdoor. The average being 95 units for indoor and 90 units for outdoor. The obstacles to vending found in different cities are listed and discussed. C. J. Babcock

65. Incentives build retail sales. T. D. LEATHERS, Milk Plant Monthly, **44**, 11: 27. 1955.

The two biggest obstacles to increased retail milk sales are overcoming the price differential between retail and wholesale milk and the reluctance of driver-salesmen to push unit sales per stop. Methods used for increasing retail sales by dairies in several of the states are discussed. C. J. Babcock

66. They work together in Indianapolis. R. B. ROBERTS. Milk Plant Monthly, **44**, 11: 29. 1955.

In Indianapolis three glasses of milk a day, every day, is a habit. This has been brought about by the Marion County Milk Marketing Area Advertising Committee. In 1935 when this committee was formed, the per capita consumption was 0.56 of a pt/day/person. In the ensuing 20 years, per capita consumption increased more than 111%. In accomplishing this it was shown that the following three things are needed for successful advertising: (1) Money, (2) Cooperation, and (3) Time. The advertising policy can be summarized as: (1) Direct the advertising to the adult population. (2) Concentrate on fluid milk the year around, (3) Co-ordinate the advertising. (4) Be consistent—give copy themes time enough to penetrate during individual campaigns. (5) Keep it simple. Most milk prospects already know

that milk is good for them, but they need to be reminded again, and again.
C. J. Babcock

67. Motivate the impulse. G. P. Gundlach, G. P. Gundlach & Co., Cincinnati, Ohio. Milk Plant Monthly, **44**, 11: 19. 1955.

The supermarket has brought about a radical change in the housewife's buying habits. She now does her food shopping by color, eye appeal, and impulses which are stimulated by clever merchandising. In 1954 the 354,640 grocery stores in the United States reported a total sales of $36,860,000,000. Supermarkets accounted for 6% of the total number of stores and for 53½% of the sales. The smaller stores, representing 75% of the total number, made only 17.6% of the sales. The greatest sales gains were made by independent supermarkets with an increase from 19% of the total market in 1953 to 22.7% in 1954. A breakdown in supermarket sales shows that 28.1% goes for fresh meat, 12.8% for produce, 8.6% for dairy goods, 4.1% for frozen foods, 2.7% for baked goods and 43.7% for all groceries. Dairy products are therefore third, surpassed only by meats and produce and the dairy department is of tremendous importance to the supermarket operators. Some of the aspects of supermarket selling are discussed and it is predicted that the supermarkets will never drive the alert retail milk operation from direct contact with the housewife because of the convenience of door-step delivery.
C. J. Babcock

68. Automatic calculators. Anon. Milk Dealer, **45**, 2: 44. 1955.

A description of an automatic calculator which in one operation: (1) Multiplies milk pounds × butterfat test, obtaining butterfat pounds, (2) Multiplies butterfat pounds × price, obtaining gross amount, (3) Subtracts deductions from gross amount, obtaining net amount, and (4) Accumulates totals of both butterfat pounds and individual check amounts.
C. J. Babcock

FEEDS AND FEEDING

69. Utilization and evaluation of grassland. Nature, **176**, 4486: 764. 1955.

This is a summary of a group of papers presented before the Section M (Agriculture) of the British Association in Bristol, England. R. A. Hamilton discussed the yield of energy of grass, silage, hay, etc. when computed on the starch-equivalent per acre basis, in various European countries and New Zealand. Yields are best in Holland and Denmark and lowest in Great Britain and France. The yield may be increased by proper management. C. Line, of the NIRD, Shinfield, England, described results obtained with various grasses. Meadow fescue proved superior to rye grass and cocksfoot. C. C. Balch, also of Shinfield, discussed the nutritive value of silage. There is an urgent need for a means of relating nutritive value of silage to its gross chemical composition. Crude fiber may serve as a guide for this purpose.
R. Whitaker

70. The feeding value of alfalfa for dairy cows when harvested and stored by four different methods. E. A. Keyes and E. P. Smith, Mont. Agr. Expt. Sta., Bozeman. Bull. 513. 1955.

A 40-acre field was divided into four equal parts and the forage harvested as loose hay, baled hay, chopped hay, and silage. The nutritive value of each type hay was determined by feeding the roughage to four groups of animals, each group containing 7 cows. Those cows fed chopped forage produced the largest amount of FCM, with the second highest producing group of cows being fed silage. The group of cows fed loose hay consumed the largest amount of TDN, while the ones which consumed silage had the highest feed efficiency. The economy of feeding one type of roughage over another depends upon the comparative production costs on a given farm. In this investigation, silage was the most economical roughage.
R. W. Hunt

71. Raising dairy calves on a limited amount of milk. F. Whiting and R. D. Clark, Expt. Farm, Lethbridge, Alberta, Canada. Can. J. Agr. Sci., **35**, 5: 454. 1955.

Three lots of 11 Holstein heifer calves were each fed on whole milk to 4 wk. of age followed by either a calf starter (with or without aureomycin) or skimmilk to 16 wk. The starter contained approx. 21% protein, all of plant origin. The calves fed skimmilk received a grain mixture containing approx. 15% protein. Starter and grain mixture were limited to a maximum of 5 lb. per head per d. Alfalfa hay was fed *ad libitum*. At 16 wk. the skimmilk fed calves were significantly heavier than those fed starter. The addition of aureomycin had no effect on wt. at 16 wk. There were no differences in height at withers or heart girth measurements at 16 or 52 wk. of age between the three lots; nor were there differences in body wt. at 52 wk.
O. R. Irvine

72. The nutritional value of rapeseed oilmeal: A review. J. M. Bell, Univ. of Sask., Saskatoon, Canada. Can. J. Agr. Sci., **35**, 3: 242. 1955.

A comprehensive review of rapeseed oilmeal is given under the headings (1) evidence for toxic factor, (2) mode of action of toxic factor, (3) counter-action of toxic factor, (4) nutrient content, and (5) current status of rapeseed oilmeal in practical livestock and poultry feeding. The bibliography contains 65 references.
O. R. Irvine

73. Preservation of grass silage with sodium metabisulfite. J. W. Bratzler, R. L. Cowan, and R. W. Swift, Pa. Agr. Expt. Sta., State College. Bull. 597-P. 1955.

The use of sodium metabisulfite as a preservative for grass silage stored in tower, trench, bunker, and stack silos is an accepted practice by many Pennsylvania farmers. The optimum rate of application is 8 lb. of bisulfite per T of forage ensiled in a tower silo, or 10 lb. per T of silage stored in trench, bunker, or stack-type silo. R. W. Hunt

74. The use of urea to increase the crude protein content of corn silage for fattening steers. O. G. Bentley, E. W. Klosterman, and P. Engle, Ohio Agr. Expt. Sta., Wooster. Res. Bull. 766. 1955.

Urea was added to corn silage at levels of 17 lb. per T of chopped corn in 1952, 54 lb. in 1953, and 25 and 20 lb. in 1954-55. It appears as though urea can be added to silage at levels up to 20 lb. per T of corn with favorable feeding results. R. W. Hunt

75. Method of processing citrus pulp. E. M. Burdick. U. S. Patent 2,724,648. 13 claims. Nov. 22, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 4: 711. 1955.

A feed for cattle made from ammoniated citrus pulp. R. Whitaker

76. Nipple for feeding liquid to young animals. G. P. Rose-Miller. U. S. Patent 2,722,217. 3 claims. Nov. 1, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 1: 65. 1955.

A teat-shaped nipple for feeding calves, etc. from a pail or other vessel. R. Whitaker

77. Ruminant feed composition containing an organic acid amide. I. J. Belasco and K. E. Walker (assignors to E. I. du Pont de Nemours and Co.). U. S. Patent 2,718,467. 10 claims. Sept. 20, 1955. Offic. Gaz. U. S. Pat. Office, **698**, 3: 461. 1955.

A feed for ruminants consisting of a nutrient for the rumen microflora and containing carbohydrates, protein, and a supplementary source of nitrogen in the form of an amide of an organic acid. R. Whitaker

GENETICS AND BREEDING

78. A new method for counting live and dead bull spermatozoa. A. D. Bangham and J. L. Hancock. Nature, **176**, 4483: 606. 1955.

The suggested technique may form the basis of a practical means of evaluating the fertility of bull semen. The semen is diluted with isotonic sodium chloride solution, buffered to pH 7.0. It is then filtered through a layer of small glass beads, which retains the dead spermatozoa and allows the live ones to pass through. The percentage of dead spermatozoa is estimated by comparing the opacity of the diluted semen before and after filtration. The filter bed consists of a layer of glass balls, having a means diameter of 200 μ. The surface is covered by a layer of larger balls (3 mm. in diameter) to protect the lower layer from being disturbed when the brine solution is poured onto it. A 1½ in. glass funnel serves as a holder, with the filtering material being held in place by a single 5 mm. glass ball in the funnel.

R. Whitaker

HERD MANAGEMENT

79. Silo construction costs and silage production practices. A. C. Magee, Texas Agr. Expt. Sta., College Station. Bull. 798. 1955.

In the Blackland and Grand Prairie areas of Texas, the three types of silos generally used are the unlined trench, concrete-lined trench, and the upright. The cost of a 100-T. size unlined trench silo was $90; for a 200-T. capacity, $122. Concrete-lined trench silos ranged in cost from $760 to $1,466. The upright concrete staved silo (100-T. capacity) cost $1,400, while the 200-T. unit cost $2,040. An annual cost of storing silage in the unlined and in the concrete-lined trenches averaged $1 and $1.40 per T. The upright silos had a storage cost of $1.65 for the 100-T. unit, and $1.29 for the 200-T. unit. When the yield was 12 T. of silage per acre, a harvest crew of five men, 2 tractors, and 2 trucks harvested 8 acres per day. When the yield was only 4 T. per acre, a crew of four men, 2 tractors, and 2 trucks put 11 acres into a trench silo in a 10-hour day. Considerably more labor was needed regardless of yield to place silage in the upright silos.

R. W. Hunt

80. Effect of pasture fertility on milk production. D. C. Brown et al., Wyo. Agr. Expt. Sta., Laramie. Mimeo. Cir. 55. 1955.

Results of 3 yr. study showed that the capacity of the bluegrass type of permanent pasture can be increased as much as 50% by applying commercial fertilizers, and the returns from increase milk yields were greater than the fertilizer costs. Nitrogen decreased the % of legumes and increased the % of grasses.

R. W. Hunt

81. Dairy calf research in La. L. L. Rusoff and J. B. Frye, Jr., La. Agr. Expt. Sta., Baton Rouge. Bull. 494. 1955.

The following recommendations are the results of this study. Calves raised for replacements should be sired by good bulls. Calves should be fed colostrum for the first 3 d. of life. They should be raised in clean, dry, individual pens. Warm whole milk (100° F.) at not more than 10% of body weight should be fed for at least 2-4 wk.; skimmilk may be fed after 2 wk. for a period of 4-6 wk. A calf starter and good quality hay can be fed starting at 7 d. of age. Carotene or vitamin A supplement must be added to the starter when whole milk feeding is discontinued. One per

cent salt, 1% oyster shell, and 1% defluorinated phosphate, or 1% salt, and 2% steamed bone-meal or di-calcium phosphate in the calf starter will supply the necessary minerals. Calves can be grouped after 4 mo. of age.
R. W. Hunt

82. Bedding device for bovine or like animal stalls. C. M. Stroup and D. L. Stroup. U. S. Patent 2,720,861. 7 claims. Oct. 18, 1955. Offic. Gaz. U. S. Pat. Office, **699**, 3: 430. 1955.

A resilient padding is described which covers the floor area of an animal stall and is held in place by clamps attached to the stall framework. R. Whitaker

83. Shut-off for continuous milking systems. R. E. Reeve. U. S. Patent 2,720,837. 2 claims. Oct. 18, 1955. Offic. Gaz. U. S. Pat. Office, **699**, 3: 424. 1955.

A system of switches for operating a vacuum type milker pump powered by an electric motor. R. Whitaker

84. Double unit pulsator and releaser combination for milking machines. C. Robson. U. S. Patent 2,721,536. 2 claims. Oct. 25, 1955. Offic. Gaz. U. S. Pat. Office, **699**, 4: 607. 1955.

Structural details are given for the construction of a milking machine pulsator.
R. Whitaker

85. Electric calf weaner. M. S. Lindstrom and S. J. Montange. U. S. Patent 2,722,912. 1 claim. Nov. 8, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 2: 254. 1955.

A shield is described which fits over a calf's nose. Two prongs, extending beyond the shield, are so arranged that they touch the calf's nose and give it an electrical shock when sucking. The electric power is provided by a battery and coil attached to the shield. R. Whitaker

86. Valve device for a milking machine. A. E. Anderson. U. S. Patent 2,723,829. 5 claims. Nov. 15, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 3: 497. 1955.

A description is given of a valve and housing for use in a vacuum operated type of milking machine. R. Whitaker

87. Strainer attachment for milking machines. L. H. Trahan. U. S. Patent 2,718,310. 5 claims. Sept. 20, 1955. Offic. Gaz. U. S. Pat. Office, **698**, 3: 422. 1955.

A cover is described for a milking pail or reservoir on a vacuum type milking machine containing a strainer or filter. R. Whitaker

88. Hoof-trimming stall. R. E. Walker. U. S. Patent 2,718,214. 7 claims. Sept. 20, 1955. Offic. Gaz. U. S. Pat. Office, **698**, 3: 397. 1955.

A stall so arranged that a standing animal is held rigidly so that its hoofs may be trimmed.
R. Whitaker

89. Fluid controlled vacuum cut-off for milking machine teat cups. G. E. Tanner (assignor to Babson Bros. Co.). U. S. Patent 2,718,208. 7 claims. Sept. 20, 1955. Offic. Gaz. U. S. Pat. Office, **698**, 3: 395. 1955.

An arrangement of two float-actuated valves within the milk receiving reservoir of a vacuum type milker which permits continuous operation of the milk and removal of the milk from the reservoir. R. Whitaker

90. Vacuum control for magnetic milking machines. A. C. Robley. U. S. Patent 2,718,871. 1 claim. Sept. 27, 1955. Offic. Gaz. U. S. Pat. Office, **698**, 4: 579. 1955.

Pulsations in the vacuum supply of a milker are produced by an arrangement of a circuit maker and breaker, and a magnetic pulsator.
R. Whitaker

91. Ventilation of farm buildings. C. H. Reed, N. J. Agr. Expt. Sta., New Brunswick. Bull. 778. 1955.

Illustrations with detail instructions show how various ventilating systems can be installed in poultry houses, livestock barns, and storage structures. R. W. Hunt

92. Milk pump assembly. L. Makous (assignor to A. O. Smith Corp.). U. S. Patent 2,725,850. 6 claims. Dec. 6, 1955. Offic. Gaz. U. S. Pat. Office, **701**, 1: 87. 1955.

An arrangement for releasing milk from a vacuum type milking machine. R. Whitaker

93. Automatic milk cock. H. W. Hein (assignor to International Harvester Co.). U. S. Patent 2,725,245. 1 claim. Nov. 29, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 5: 892. 1955.

A valve mechanism is described which automatically permits a vacuum type milker to be uncoupled without loss of vacuum.
R. Whitaker

94. Device for preventing the introduction of ferric substances into the digestive tract of an animal. E. B. Ritchey. U. S. Patent 2,725,037. 2 claims. Nov. 29, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 5: 839. 1955.

A device for removing iron particles from the feed of cows and other domestic animals. A clamp which is fastened in the cows' nose holds a magnet in such a position that a magnetic field is created adjacent to the mouth of the animal. R. Whitaker

95. Ice bank control. J. J. Rothwell (assignor to Penn Controls, Inc.). U. S. Patent 2,724,950. 4 claims. Nov. 29, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 5: 816. 1955.

A pressure responsive actuating control mechanism is described for maintaining a temperature near that of melting ice in a cabinet containing water for cooling milk in cans.
R. Whitaker

ICE CREAM

96. Pa. Supreme Court issues historic decision; reverses lower tribunal in ice milk case. ANON. Ice Cream Trade J., **51**, 56: 10. 1954.

In one of the most historic decisions affecting the ice cream industry, the Supreme Court of Pennsylvania on September 27 at Harrisburg, Pa., revised the ruling of the Dauphin County Court of last year and in effect legalized ice milk in the state of Pennsylvania.

W. H. Martin

97. 1955 Super-market survey on ice cream. ANON. Ice Cream Trade J., **51**, 10: 50. 1955.

The ave. supermarket today sells between 9,000 and 10,000 gal. of ice cream annually, compared to 6,000 gal. two yr. ago. The ½-gal. package predominates. Most stores sell at least two brands, and 65.9% of the stores sold their own private label among the brands offered for sale. There was a wide range of prices. Pints sold from 15¢ to 49¢, qt. sold from 25¢ to 29¢ to 85¢ to 94¢, and ½ gal. from 45¢ to $1.84, with 85 to 94¢ the most popular price. Supermarkets are interested in selling cup, cake rolls, and specialties, with about 30% of the stores reporting some success with these items. W. H. Martin

98. Analysis of the 1954 volume in mellorine. ANON. Ice Cream Trade J., **51**, 8: 18. 1955.

Mellorine was made in 10 states in 1954. Texas was the leading state with a production of 17.6 million gal., accounting for 56% of the total production in the United States. Production in 1954 in 1,222 plants was 31,416,000 gal.

W. H. Martin

99. Sanitary procedures for soft-serve stores. J. J. SCHEURING, Univ. of Ga., Athens. Ice Cream Trade J., **51**, 8: 44. 1955.

Specific sanitation problems which soft-serve stores operators should check and remedy are discussed. Some of the problems discussed include store surroundings, store interior, personnel, and methods, and the condition of equipment.

Store operators should ask themselves frequently the following questions: "Is the store attractive in design and structure?" "Is it clean in appearance?" "Is it inviting to the customer?" "Does it give the impression that the store is meticulously clean and that I am proud of my business?" "And what can I do to make my store more attractive and convenient for the public?" W. H. Martin

100. Honey in low-calorie frozen desserts. P. H. TRACY, Dept. of Food Technol., Univ. of Ill., Urbana. Ice Cream Trade J., **51**, 9: 52. 1955.

The use of honey as a sweetener for low-sugar mixes is suggested. A mix containing 6% fat, 7% milk solids-not-fat, 4% special protein, 8% honey, 0.5% stabilizer and emulsifier and 0.16% calcium sucaryl is described.

In 100 g. of this mix there will be approximately 120 cal. The carbohydrate value per 100 g. of mix will be about 44 cal.

Approval for the sale of a product should be obtained from the proper officials. It must not be labeled ice cream and the calorie and carbohydrate value per 100 g. of finished product should be printed on the carton. The presence of artificial sweetener should be declared on the package. W. H. Martin

101. Shipping liquids in plastic-lined fiber cartons. ANON. Milk Prod. J., **46**, 11: 17. 1955.

Liquid ice cream mix and ice milk mix is now being successfully shipped in five-gallon fiber cartons that have polyethylene liners. This innovation is saving money in shipping costs for the Rochester Dairy Co-operative. Advantages of the new container to the mix buyer are listed. J. J. Janzen

102. Ice cream mix pasteurization with Hi-Heet unit. ANON. Ice Cream Rev., **39**, 3: 60. 1955.

Ice cream mix pasteurization is accomplished with a Roswell Hi-Heet process unit at a temperature of 220° F. with a 27-sec. holding period. Operating at this temperature the unit can pasteurize 13,900 lb. of mix/hr. Satisfactory results were also obtained by using a temperature of 252° F. with a 3-sec. hold. The unit is set up for cleaning in place.

W. J. Caulfield

103. Dry whey as an ingredient in sherbet and ice cream. ANON. Ice Cream Rev., **39**, 3: 108. 1955.

Results of experimental work and opinions expressed by ice cream manufacturers indicate that high quality (U.S. extra grade) dry whey can be advantageously used in either sherbet or ice cream.

Possible disadvantages of using whey solids in ice cream are the danger of sandiness unless the amount of whey solids is limited, and the possibility of a slightly inferior flavor unless the whey solids are of high quality.

Since spray process dry whey which meets U.S. extra grade standards is readily available it would appear that it can be successfully used in either sherbet or ice cream.

W. J. Caulfield

104. Vending half-gallons of ice cream. ANON. Ice Cream Rev., **39**, 4: 46. 1955.

A combination ½-gal. ice cream and milk vending machine is described. The vendor, located in a residential district of Grand Rapids, sold over 900 gallons of ice cream in a period of 27 days.

Convenience, quality product, and proper pricing are the three factors thought to be responsible for the success of the vendor. Half-gallons sold thru the vendor have been priced at 65¢ in comparison with a price of 79¢ when sold thru stores.

The vendor has a capacity of 200 ½-gal. and 150 pt. packages of ice cream. In addition, storage space for 200 gal. of ice cream is provided beneath the conveyors. The vendor is 13 ft. wide, 8 ft. deep and 11 ft. high. Refrigeration is supplied by one 2-h.p. and one ½-h.p. compressor. The compressors are both air-cooled. Milk can also be vended from the same machine by adding two additional conveyor belts.

It is estimated that electric current for the vendor will average approximately $45.00 per mo. and that the total cost of operation including depreciation, repairs, location rental, etc. will average $100 per mo. The vendor is designed to sell 10,000 gal. of ice cream per year. Sales of 20 ½-gal. of ice cream and 50 ½-gal. of milk per day will show a profit for the machine. W. J. Caulfield

105. Bulk handling of mix for soft-serve operations. ANON. Ice Cream Rev., **39**, 4: 54. 1955.

The bulk handling of mix for a group of soft-serve stores located within a radius of 120 miles from Bradford, Pa. is described. Each store is equipped with a 160-gal. tank, which is hung from an overhead scale. The tank and scale are located in a walk-in cooler. The mix is weighed into the tank and the amount of mix on hand at any time can be determined by weight. W. J. Caulfield

106. Polyethylene-lined fiber cartons for ice cream mix. ANON. Ice Cream Rev., **39**, 3: 84. 1955.

Liquid ice cream and ice milk mix is being successfully distributed by the Rochester Dairy Cooperative, Rochester, Minn. in 5-gal. fiber cartons with a polyethylene liner. The advantages of this type of shipping container to the mix buyer are discussed.

W. J. Caulfield

107. Apparatus for making variegated ice creams and like substances. A. C. ROUTH. U. S. Patent 2,722,177. 5 claims. Nov. 1, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 1: 55. 1955.

Details are given for a device for continuously injecting a fruit or other flavored syrup into a stream of ice cream from a freezer.

R. Whitaker

108. Agitating device for making ice cream and the like. J. W. MORGAN. U. S. Patent 2,719,031. 1 claim. Sept. 27, 1955. Offic. Gaz. U. S. Pat. Office, **698**, 4: 622. 1955.

A small motor operates a shaft which causes beaters to rotate and agitate ice cream mix in a home refrigerator tray. R. Whitaker

109. Ice cream dispensing mechanism. N. E. SPIESS, JR. and A. R. ADLER (assignors to National Dairy Research Laboratories, Inc.). U. S. Patent 2,719,494. 13 claims. Oct. 4, 1955. Offic. Gaz. U. S. Patent Office, **699**, 1: 61. 1955.

A device for dispensing individual size scoops of ice cream in bulk containers in refrigerated cabinets. The scoop is moved by a rack and pinion attached to a piston operated by fluid pressure. The scoop is lined with a diaphragm which discharges the ball of ice cream when fluid pressure is applied to the scoop side of the diaphragm. R. Whitaker

110. Ice cream sandwich package. J. A. DUKE (assignor to Rite Pack Co.). U. S. Patent 2,725,178. 1 claim. Nov. 29, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 5: 875. 1955.

A combination mold and package for ice cream sandwiches. The wafers are held in place in the assmbled package and the ice cream filled into the space between them. Perforations in the paper permit easy segregation of a single package containing one sandwich, from a series of packages. R. Whitaker

111. Packages for frozen pops. P. SCHENK. U. S. Patent 2,724,539. 5 claims. Nov. 22, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 4: 684. 1955.

A popsicle mold made of paper, comprising a series of tapered compartments which may be filled, frozen, and handled as a single unit. The molds are made separable by means of tear lines. Sticks may be inserted through slits in the folded top flaps. R. Whitaker

MILK AND CREAM

112. Bedoemmelse af produktionsmaelkens hygiejnisk-bakteriologiske kvalitet. (Determination of the bacteriological quality of manufacturing milk). (English summary). A. J. OVERBY, Royal Vet. and Agr. Coll., Copenhagen. Communication from the Department of Dairy Research, 1-80. 1955.

As part of a program to improve the quality of manufacturing milk in Denmark a study was conducted to determine the test(s) best suited for grading of such milk. Twenty-two methods were used to grade the milk from 1001 producers. The survey lasted from Feb. through Nov.

On the basis of the numerous results it was recommended to use either Wilson's modification of the methylene blue test or the 3-hr. resazurin test during the summer months. Organoleptic sampling of the milk supplemented every other week with Wilson's methylene blue test on pasteurized producer samples was recommended for use during the winter months.

A more severe deduction in the milk price than used at the present or payment of a premium was recommended to enforce and maintain high standards. The latter had been tried

on an experimental basis in one cooperative dairy and resulted in a large increase in the number of producers getting their milk in Class I. T. Kristoffersen

113. Special low sodium milk hits new markets. ANON. The Milk Dealer, **45**, 2: 51. 1955.

Three years of research have brought about a process known as ion-exchange for making a Lo-Sodium Fresh Milk. It eliminates 90% of the sodium content. The process is carried out at approximately 35°-40° F. and does not alter the pH of the milk. The milk is then homogenized, pasteurized, cooled, and bottled. Each quart contains 675 calories, 5% carbohydrate, 4.7% lactose, 3.5% protein, 3.5% butterfat, and less than 50 mg. of sodium. C. J. Babcock

114. Home consumption of milk. D. DICKINS, Miss. Agr. Expt. Sta., State College. Cir. 198. 1955.

This report shows the consumption of milk products by 503 urban and 518 rural families located in Miss. The urban families had a weekly per capita consumption of dairy products equivalent to 4.29 qt. of fluid milk, while the rural families consumed 5.17 qt. There was greater difference between low and middle income families in regard to the amount of dairy products consumed than between the middle and higher income families. About ⅛ of the rural families and ¼ of the urban families in the high income group did not consume the recommended amount of dairy products. On the other hand, 57% of the rural and 40% of the urban families in the lowest income group, did consume the recommended amounts. About ¾ of the whole milk and ½ of the skim and buttermilk were consumed as a beverage by both urban and rural families. A program designed to promote the consumption of milk should emphasize two points: (1) the most economic means for the low income families to purchase dairy products, and (2) the necessity for those in the high income group to consume a required amount of dairy products.

R. W. Hunt

115. Economic effect of bulk milk handling in Vermont. R. O. SINCLAIR, Vt. Agr. Expt. Sta., Burlington. Bull. 581. 1955.

Among the more important advantages of bulk handling are: (1) An opportunity for a better quality milk, (2) A saving in labor during the milking operation, (3) An increased return of as much as 3¢/cwt. from savings in shrinkage, (4) A saving of 2¢/cwt. from the elimination of cans, (5) Milk purchased on farm, (6) Possibility of lower hauling costs, and (7) Opportunity of receiving premium for milk. Some disadvantages are: (1) More quality control problems, (2) Fewer market outlets, (3) Less competition among haulers, and (4) Very high initial investment.

R. W. Hunt

116. Milk dispenser. W. J. TAMMINGA (assignor to Monitor Process Corp.). U. S. Patent 2,718,985. 23 claims. Sept. 27, 1955. Offic. Gaz. U. S. Pat. Office, **698**, 4: 609. 1955.

A refrigerated cabinet for holding a bulk milk can with a bottom outlet. A recess in the cabinet door provides for the dispensing tube.

R. Whitaker

117. Sour cream dairy product. R. A. PAGE and V. G. LAVALIE (assignors to Kraft Foods Co.). U. S. Patent 2,719,793. 1 claim. Oct. 4, 1955. Offic. Gaz. U. S. Pat. Office, **699**, 1: 141. 1955.

Cream containing 7-12% fat is pasteurized and homogenized with 2.6-2.9% protein. After ripening with lactic starter to a whey acidity of 0.7-0.9%, the mass is heated to 165° F. Whey is returned to the curd to increase the protein to 3.0% or more, and this high protein mixture is heated to 145° F. and homogenized to form a sour cream-like product.

R. Whitaker

118. Apparatus for testing cream. W. N. KAISER. U. S. Patent 2,724,263. 9 claims. Nov. 22, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 4: 613. 1955.

A sediment tester for cream is described. The cream is forced through a filtering disc by means of a fluid overlaid on the cream and confined under pressure in the vessel holding the sample.

R. Whitaker

MILK SECRETION

119. Rate of milk secretion with increasing interval between milking. G. M. ELLIOTT and P. J. BRUMBY. Nature, **176**, 4477: 350. 1955.

Experiments are described which were designed to determine if milk secretion declines with time during the interval between successive milkings. The literature is controversial on this subject. Residual milk was removed with 10 I.U. of "Pitocin." The effect of the preceding interval was eliminated by interposing 12-hr. intervals between all milkings. The data presented show that no significant decline is noted before 20-24 hr. in both milk and fat secretion as the milking interval is varied. There was some indication that an increase in length of the interval preceding the experimental interval has a deleterious effect on milk production and a beneficial effect on fat secretion. This is probably concerned with the effect of an increasing amount of residual milk and/or an increasing length of time of the preceding interval rather than to a direct pressure effect of the increasing amount of milk in the udder.

R. Whitaker

120. Evaluation of mammary-gland development in Holstein and Jersey calves as a measure of potential producing capacity. W. W. SWETT, et al., U.S.D.A., Washington, D. C. Tech. Bull. 1111. 1955.

Since 1927, udders of Holstein and Jersey heifers in the herd at Beltsville have been examined routinely at ages of from 1-18 mo. The data obtained from making 2,000 palpation examinations of 200 animals were used in establishing a pattern or "standard" to show the expected size and form of the mammary gland and to provide a means of comparison. A numerical system was adopted consisting of 9 grades, in which grade 5 was assigned as the "average" or "standard" mammary system. A grade number in excess of 5 designates a greater capacity udder than does a grade below 5. A nomogram can be developed by applying a formula to the basic data for any calf to obtain a direct reading of the palpation grade for mammary gland development, thereby eliminating the element of human judgment.

At calf ages up to 6 mo., a significant correlation exists between the palpation grade and production in the first lactation. Correlation of palpation grades observed after 6 mo. was either very low or negative. The most effective age for grading mammary gland development, as a means of evaluating potential producing capacity, was found to be 5 mo. for Holsteins and 4 mo. for Jerseys. Of the three variables studied (stage of development, width of gland, or length of gland), the highest correlation for Holsteins existed between width of gland and production; while for Jerseys, stage of lactation was the highest. Highly significant correlations existed between palpation grade and body weight for both breeds. R. W. Hunt

NUTRITIVE VALUE OF DAIRY PRODUCTS

121. Food value of dairy products. Anon. Nat'l. Dairy Research Labs., Oakdale, N. Y. 1955.

This booklet presents the composition of dairy products in two tables. The first table shows the nutrients found in 100 g. portions of 26 dairy products. The second table shows the composition based on a common serving (glass, cup, ounce, tablespoon, or teaspoon) of 25 different dairy products. The group classification of these items are: milk, cream, butter, ice cream, sherbet, cottage cheese, and cheese. A brief discussion of the need for fat, protein, carbohydrates, various minerals and vitamins in human nutrition also is presented.
R. W. Hunt

PHYSIOLOGY AND ENDOCRINOLOGY

122. Physiological studies of the vagal nerve supply to the bovine stomach. II. Studies on the eructation mechanism in adult cattle. H. E. Dziuk and A. F. Sellers, Minn. Agr. Expt. Sta., St. Paul. Am. J. Vet. Research, **16**, 61: 499. 1955.

Electrodes were applied to the dorsal vagal trunks of 3 adult cows with rumen fistulas. Tracings of the rumen sacs, reticulum, and cardia were made with and without electrical stimulation, and while the rumen was kept distended by constant air insufflation or by infusion of 22 to 25 gal. of water. Moderate vagal stimulation caused more frequent eructation and swallowing than normal. Strong vagal stimulation caused spasmodic contraction of the rumen, reticulum, and cardia. Submersion of the cardia by 6 to 8 in. of water did not prevent normal eructation in 2 of the 3 cows.
E. W. Swanson

123. The effect of feeding sweet clover silage on the prothrombin time of blood of cattle. W. J. White, J. E. R. Greenshields, and W. Chubaty, Dom. Forage Crop Lab. and Univ. of Sask., Saskatoon, Canada. Can. J. Agr. Sci., **34**, 6: 601. 1954.

Significantly higher prothrombin times were found in two herds of cattle being fed sweet clover silage. In one herd on similar roughage prothrombin time was normal. In one affected herd, silage of a non-mouldy, dark-brown quality was fed almost entirely for 10-14 d. before the study. In the other affected herd the daily ration consisted of about 25% of dark-brown silage and 75% of good quality silage. In the unaffected herd the dark-brown silage was fed about once a week and good quality silage the remainder of the time. It is considered that an anti-coagulant developed in the mouldy and dark-brown sweet clover silage. The anti-coagulant is assumed to be dicumarol.
O. R. Irvine

124. Relationship between orotic acid and animal protein factor of casein. R. Viviani, M. Marchetti, A. Rabbi, and G. Moruzzi. Nature, **176**, 4479: 464. 1955.

Rats were fed from weaning on an animal protein factor (APF) deficient diet supplemented with 1,000 γ of orotic acid per 100 g. of food. The results indicate that orotic acid may be one of the growth-factors for rats deficient in APF, but not for normal rats. A relationship is indicated between orotic acid and the APF's of casein. R. Whitaker

SANITATION AND CLEANSING

125. Simplified dairy waste treatment. R. R. Kountz, Penn. State Univ. Milk Prod. J., **46**, 11: 10. 1955.

A simple economical waste treatment plant is described as a single oxidation tank and an adequate oxygen suply so that the biological culture is maintained aerobic at all times. The waste is added to this tank, and the biological culture removes the milk solids, and the treated waste is decanted; all in a 24 hr. cycle. The operating personnel time is less than two hr. per day, which is mainly the routine maintenance time to clean the trash screen and check the mechanical equipment. There is no odor. There is no sludge disposal. There are no laboratory tests nor personal decisions required.

Since milk is perfect food for both man and for bacteria, milk waste is the simplest, easiest, and quickest waste to treat.

Specific details of plans and operation of such a waste disposal unit are also presented and discussed.

The Pennsylvania State developed method costs $12,000-$14,000 to construct with operating and fixed charges of $15 per day. Cost figures for waste treatment, in dairies receiving more than 50,000 lb. of milk per day as well as less, are presented. J. J. Janzen

126. Iodine and sanitation. L. GERSHENFELD, Dept. of Bacteriol., Philadelphia Coll. of Pharmacy, Pa. J. of Milk and Food Technol., **18**, 9: 220. 1955.

Acid-buffered iodine-iodide solutions and commercial iodophors are effective as sanitizing agents in concentrations from 25 to 75 p.p.m. of free iodine. This concentration is equivalent to 200 p.p.m. available chlorine.
H. H. Weiser

127. A simplified procedure for sanitizing glasses at soft drink stands. H. HELLMAN and H. SHUVAL, Div. of Sanitation, Min. of Health, Jerusalem, Israel. J. of Milk and Food Technol., **18**, 9: 215. 1955.

A simplified method of washing and sanitizing drinking glasses used in soft drink stands in Israel was developed. A pressure spray served as a pre-rinse and final rinse, while the brushing, detergency, and sanitizing phases were combined into one operation using a specially designed brush-container filled with a detergent-sanitizer.

A quaternary ammonium compound detergent-sanitizer (1,000 p.p.m.) was satisfactory, and superior to hypochlorite detergent-sanitizer. H. H. Weiser

128. A comparison of the effect of four milking machine cleaning and sanitizing procedures on the standard plate count of raw milk. G. W. WATROUS, E. M. KESLER, and H. V. ATHERTON, Penn. State Univ., University Park. J. of Milk and Food Technol., **18**, 11: 284. 1955.

No significant differences in bacterial counts of milking machines were noted when a good cleaning procedure was followed with lukewarm water rinse prior to use of either chlorination, quaternary ammonium cleaner-sanitizer, or lye rack storage. H. H. Weiser

129. Washing machine for centrifuge-discs. H. DE JONGE. U. S. Patent 2,721,568. 4 claims. Oct. 25, 1955. Offic. Gaz. U. S. Pat. Office, **699**, 4: 615. 1955.

A U-shaped wash tank for washing separator or clarifier discs. A hinged cover is provided and also a frame and rack which facilitates lifting the discs in and out of the tank.
R. Whitaker

130. Can washer. W. J. TAMMINGA. U. S. Patent 2,725,064. 10 claims. Nov. 29, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 5: 846. 1955.

A rising jet type of can cleaner in which the nozzle rotates as the feeder pipe is reciprocated into and out of an inverted milk can.
R. Whitaker

131. Power washing cream separator metering valve. J. R. ORELIND, H. W. HEIN, and J. PAPLASKI (assignors to International Harvester Co.). U. S. Patent 2,725,178. 15 claims. Nov. 29, 1955. Offic. Gaz. U. S. Pat. Office, **700**, 5: 877. 1955.

A float-operated valve is described which permits the introduction of a cleaning mixture into a milk separator. R. Whitaker

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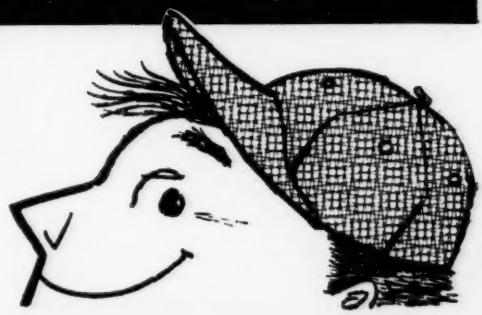
The fact that more and more milk producers use Rapid-Flo day after day than any other brand, shows proof—in use—of the superiority of Rapid-Flo over any other filter regardless of claims or price.

It also indicates that producers want to do their part in improving milk quality by using a filter disk that's safe and reliable.

So when you urge producers to use Rapid-Flo Fibre-Bonded Filter Disks and the Rapid-Flo Check-Up for mastitis and sediment, they know you're giving the best advice about improving quality and reducing cost and they cooperate willingly—as thousands of sanitarians know today.

It's the kind of teamwork that helps the industry by helping individuals do a better job. Johnson & Johnson will continue to do its part by turning out the best possible filter media at the lowest possible cost.

Filter Products Division — Johnson & Johnson — 4949 West 65th Street Chicago 38, Illinois



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- In running quality control tests on your products, accuracy, as you know, is a first essential. And accurate results depend upon precision-engineered laboratory equipment and accessories.
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Babcock Bottle Washers

Stainless Steel Acid Bottle Trunnions

Hilker-Guthrie Sour Cream Body Testers

- Bulletin 312-9 provides full information about the Mojonnier line of precision laboratory equipment. Send for it today.

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1922 With Prof. Iverson, G. P. Gundlach does *Butter Pecan Ice Cream* research.
1929 Selling slogan, "One of the Good Things of Life," created for ice cream.
1930 Dominations and wide use of fruit symbols started by Gundlach Company.
1931 First Feature Flavor-of-the-month presented to Ice Cream Industry by Gundlach.
1933 Dairy Manufacture and Research Bureau organized by Gundlach for Ice Cream Industry.
1935 First Mass Dealer Meeting . . . another Gundlach "first."
1937 First Weatherproofed Vehicle Cards for Ice Cream Trucks introduced.
1938 Lemon Chiffon Ice Cream introduced to Ice Cream Industry for first time anywhere.
1939 Caracas Chocolate comes from Gundlach laboratory.
1940 "Romance" Ice Cream presented for first time in unique promotion.
1941 "Sweetheart" Ice Cream originated by Gundlach.
1942 Pineapple Nut Ice Cream presented for first time.
1943 First Variegated Ice Cream under trade name of "Twirl."
1945 Gundlach presents first Ice Cream Cartons with life-like illustrations.
1946 First G. P. Gundlach & Company National Clinic for Ice Cream Manufacturers held.
1948 Grenadier Black Sweet Cherry Ice Cream introduced nationally by Gundlach.
1949 Fro-Zerta, low fat frozen dessert introduced as Gundlach Franchise.
1950 Gundlach's famous Peach Ice Cream program makes appearance.
1952 G. P. Gundlach extends Ice Cream merchandising service to Europe.
1954 Italian Marrons imported for first time as ingredients for Ice Cream.
1955 Sensational Dutch Apple Ice Cream introduced by Gundlach Company.
1956 Strawberry-Rhubarb & Blueberry Ice Creams introduced by Gundlach.

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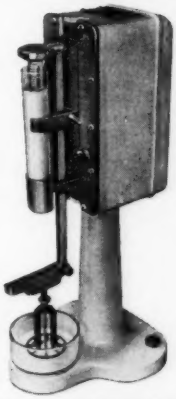

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